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An author desiring to submit a manuscript for publication should send it to the Editor, William J. Robbins, American Philosophical Society, 104 South Fifth Street, Philadelphia 6, Pa.

NAVIGATION—FROM CANOES TO SPACESHIPS

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(*Read November 12, 1959*)

INTRODUCTION

In 1786 John Hyacinth de Magellan of London presented two hundred guineas to the American Philosophical Society as a gift, through which special gold medals were to be awarded from time to time. Under the terms of the gift, each of these medals should go "to the author of the best discovery or most useful invention relating to navigation, astronomy, or natural philosophy (mere natural history only excepted)." This specification of conditions makes it very probable that the donor intended to honor his lineal ancestor Ferdinando Magellan, who was killed during a Philippine Islands battle in April of 1521, after having navigated across all the unknown longitudes of the world's oceans. This earlier Magellan, the illustrious first circumnavigator of the globe, was a man whose vision, boldness, leadership, steadiness in adversity, and actual achievements give him an unassailable position as a very great member of the human race. It is a high honor for the author of this paper to be identified in any way with the name of Magellan, and he is deeply grateful to the American Philosophical Society for the 1959 Magellanic Medal. The citation mentions contributions to inertial guidance, a field in which the author has been active for many years as Director of the Instrumentation Laboratory at the Massachusetts Institute of Technology. In this position, he has been fortunate to have the collaboration of a dedicated and able group of scientists and engineers who must rightfully receive a great share of any credit that may be due for pioneering applications of inertial devices to the problems of navigation.

Inertial navigation is properly the subject of primary interest for this paper, but a brief discussion of guidance in general is needed to bring out an over-all picture, with the inertial method given its place as one segment of a generalized pattern. To be complete, this pattern must include the navigational means that have been used or are available for terrestrial, marine, aeronautical, and space vehicles ranging from the dugout canoes of our caveman ancestors to the interplanetary ships that will be built in the near future for explorations of the solar system. Historical coverage and details of particular devices are beyond the scope of this paper, which is concerned only with the basic principles and methods that are used to solve the problems of navigation. Accordingly, references are omitted from the text, but a short bibliography related to gyroscopic devices and inertial navigation is provided for the convenience of those readers who may be interested in pursuing the subject further.

PRIMITIVE NAVIGATION

When one of our remote ancestors wished to go on a trip, he selected landmarks within sight and took his guidance from first one and then another, until he reached his destination (fig. 1).[1] If night or bad weather prevented him from seeing any landmark, he was forced to stop until conditions improved. Navigation with restrictions of this kind limited voyages to waters near extended shore lines and islands, except for a few special cases where boats might be moved by known wind and water currents. This complete dependence on currents or on visible terrestrial objects was relieved many centuries ago by the discovery that under proper conditions heavenly bodies could be used to assist travel over the surface of the earth. In effect, the stars were found to act as points in a knowable space located

* On April 24, 1959, the Society in Executive Session voted to award the Magellanic Premium to Dr. Draper in recognition of his pioneer work, culminating in the invention, research and practical development of an inertial navigation system now applied to airplanes, missiles, submarines, and ships, without need for visual or radiation references. The Magellanic Medal was presented to Dr. Draper on November 12, 1959.

[1] The figures are drawn so as to be self-explanatory; hence, little detailed discussion of the figures appears in the text.

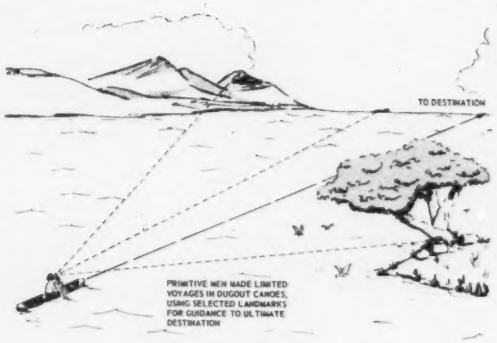
TO DESTINATION
PRIMITIVE MEN MADE LIMITED VOYAGES IN DUGOUT CANOES, USING SELECTED LANDMARKS FOR GUIDANCE TO ULTIMATE DESTINATION

FIG. 1. Visual line-of-sight navigation.

at a great distance from the earth (fig. 2). The sun, the moon, and the planets did not appear to be fixed in this space, but followed paths that reduced their usefulness for the purposes of guidance. On clear nights, the star Polaris showed the direction of north and provided information on latitude by its angle above the horizon. Other stars with known positions in the pattern of the celestial sphere were also used, but celestial navigation remained an incomplete art for many centuries. The principal reason for this imperfection was the earth's rotation, which made it impossible to determine the angular position of the earth with respect to the stars. Without good information on this position, estimates of longitude necessarily remained of low quality.

CELESTIAL NAVIGATION

The key problem in longitude measurements was that of finding the rotational angle of the earth with respect to a reference position having known relationships to points fixed on the celestial sphere. Astronomical knowledge recorded in star tables and almanacs easily gave angles between lines of sight to celestial objects and the vertical at any terrestrial point, if the earth could be assumed to remain in a particular position. In practice, the earth never fulfilled this assumption, but continuously moved with respect to any possible reference position. Because the angular velocity of the earth among the stars was and is effectively constant and well known, an accurate means for indicating sidereal time (time based on rotation of the earth referred to the celestial sphere) would have made it possible to find longitude by fixing the angle of the earth from a selected reference position.

The basic problem of timekeeping for navigation was first solved during the eighteenth century by John Harrison, who received a prize from the British Admiralty for his achievement. The nineteenth-century developments of instruments and other devices that accompanied and followed Harrison's work on the marine chronometer—improved sextants, logarithmic multiplication, almanacs, and other aids—brought the art of celestial navigation by visual observations very close to the high level that it has today.

Celestial navigation is basically the art of using

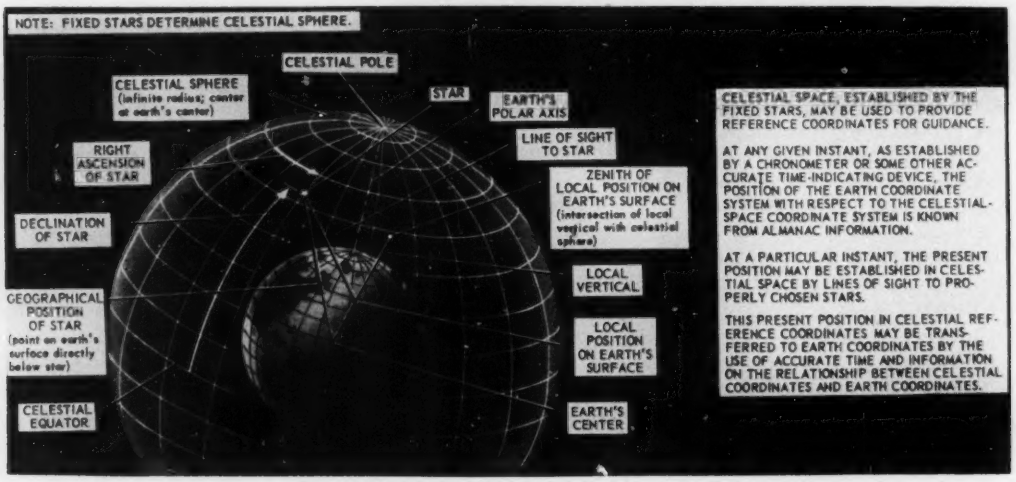
NOTE: FIXED STARS DETERMINE CELESTIAL SPHERE.
CELESTIAL POLE
CELESTIAL SPHERE (infinite radius; center at earth's center)
STAR
EARTH'S POLAR AXIS
LINE OF SIGHT TO STAR
RIGHT ASCENSION OF STAR
ZENITH OF LOCAL POSITION ON EARTH'S SURFACE (intersection of local vertical with celestial sphere)
DECLINATION OF STAR
LOCAL VERTICAL
GEOGRAPHICAL POSITION OF STAR (point on earth's surface directly below star)
LOCAL POSITION ON EARTH'S SURFACE
CELESTIAL EQUATOR
EARTH'S CENTER
CELESTIAL SPACE, ESTABLISHED BY THE FIXED STARS, MAY BE USED TO PROVIDE REFERENCE COORDINATES FOR GUIDANCE.
AT ANY GIVEN INSTANT, AS ESTABLISHED BY A CHRONOMETER OR SOME OTHER ACCURATE TIME-INDICATING DEVICE, THE POSITION OF THE EARTH COORDINATE SYSTEM WITH RESPECT TO THE CELESTIAL-SPACE COORDINATE SYSTEM IS KNOWN FROM ALMANAC INFORMATION.
AT A PARTICULAR INSTANT, THE PRESENT POSITION MAY BE ESTABLISHED IN CELESTIAL SPACE BY LINES OF SIGHT TO PROPERLY CHOSEN STARS.
THIS PRESENT POSITION IN CELESTIAL REFERENCE COORDINATES MAY BE TRANSFERRED TO EARTH COORDINATES BY THE USE OF ACCURATE TIME AND INFORMATION ON THE RELATIONSHIP BETWEEN CELESTIAL COORDINATES AND EARTH COORDINATES.

FIG. 2. Geometrical relationships between terrestrial and celestial coordinates.

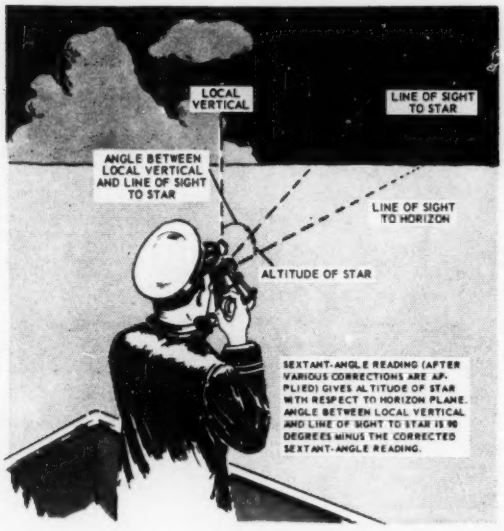
LOCAL VERTICAL
LINE OF SIGHT TO STAR
ANGLE BETWEEN LOCAL VERTICAL AND LINE OF SIGHT TO STAR
LINE OF SIGHT TO HORIZON
ALTITUDE OF STAR
SEXTANT-ANGLE READING (AFTER VARIOUS CORRECTIONS ARE APPLIED) GIVES ALTITUDE OF STAR WITH RESPECT TO HORIZON PLANE. ANGLE BETWEEN LOCAL VERTICAL AND LINE OF SIGHT TO STAR IS 90 DEGREES MINUS THE CORRECTED SEXTANT-ANGLE READING.

FIG. 3. Use of the sextant in celestial navigation.

the celestial sphere as a reference space in which visible stars provide geometrical points for relating positions in terrestrial space to a system of coordinates outside the earth. These star lines of sight are the directions from which angles to the local vertical are observed at the terrestrial point to be located, by means of instruments like the sextant (fig. 3). Angle measurements of this kind are useful in navigation only if the positions that the observed stars occupy on the celestial sphere are known and if the instantaneous orientation of a selected meridian fixed to the earth is measured with respect to the celestial sphere.

Data on celestial-sphere points are available from the body of knowledge developed in descriptive astronomy and are recorded for the purposes of navigation in star tables and almanacs. The meridian selected as the reference for navigation is arbitrarily taken as the one passing through Greenwich. At any instant, the hour angle of this meridian may be determined with the aid of a chronometer reading, which provides knowledge of the time elapsed since the Greenwich meridian last occupied a reference orientation with respect to the celestial sphere. The hour angle, star observations, and almanac data are the elements used to find locations on the earth by conventional methods of navigation.

The geometrical principles associated with the use of a nonterrestrial reference space for the purposes of navigation have been known and applied for centuries. Many techniques for using these principles, differing in details from the process that has been described, are possible. This fact is not important for the purposes of this paper, which is primarily concerned with describing the place of inertial methods among other ways of locating points on the earth's surface. It will appear that inertial navigation is geometrically analogous to celestial navigation. The essential difference lies in the use by inertial systems of gyroscopically controlled, rigid body members to serve the functions of the celestial sphere as a nonterrestrial reference space.

NAVIGATION BY RADIO AND RADAR

Navigation by the use of terrestrial landmarks, a very old art, was revolutionized during the first decades of the twentieth century by the new science of electronics. This revolution came from applications of radio techniques to maintain radiation links between vehicles and points with known locations on the earth by the use of electromagnetic radiation having wave lengths much longer than those of visible light (fig. 4). Darkness, bad weather, distance, and obstructions that affect visual observations do not interfere with these long-wave-length contacts with landmarks that are radio stations or reflectors.

Radio direction finders are now common equipment for aircraft and marine vessels and serve as basic aids to navigation by giving bearings to known stations. Signals set up in the fashion of the "A" and "N" quadrants that are associated with the radio beams of civil airways have been used for several decades to guide airplanes. Higher accuracy and wider coverage in fixes are possible by applying the principles of loran, and similar radio-navigation systems, in which the navigating vehicle receives synchronized pulse signals from at least three transmitting stations (fig. 5). The time difference between the signals

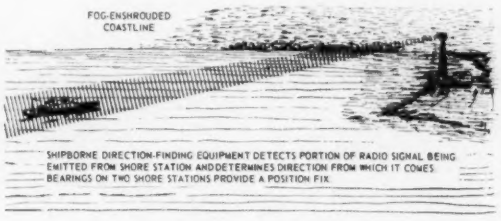
FOG-ENSHROUDED COASTLINE
SHIPBORNE DIRECTION-FINDING EQUIPMENT DETECTS PORTION OF RADIO SIGNAL BEING EMITTED FROM SHORE STATION AND DETERMINES DIRECTION FROM WHICH IT COMES. BEARINGS ON TWO SHORE STATIONS PROVIDE A POSITION FIX.

FIG. 4. Application of radio techniques to terrestrial navigation.

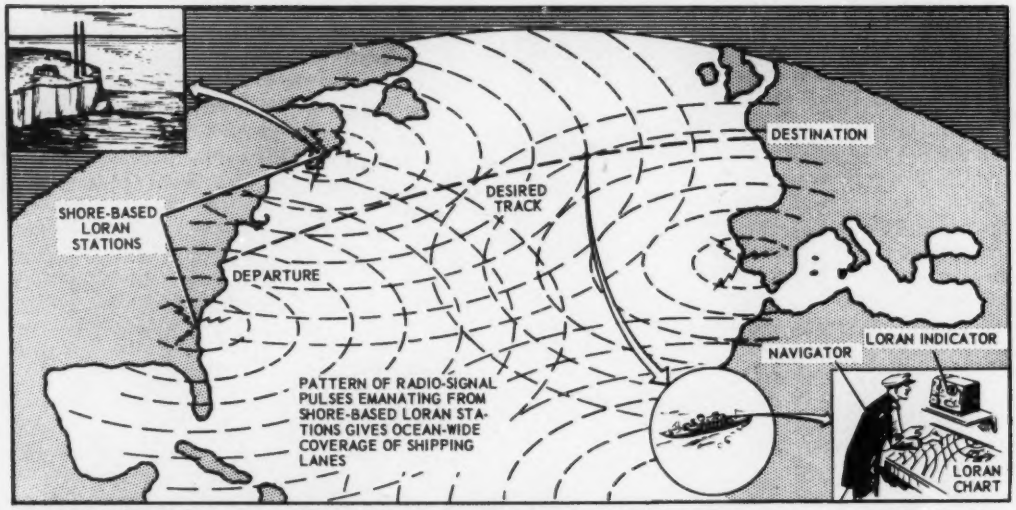
DESTINATION
DESIRED TRACK
SHORE-BASED LORAN STATIONS
DEPARTURE
NAVIGATOR
LORAN INDICATOR
PATTERN OF RADIO-SIGNAL PULSES EMANATING FROM SHORE-BASED LORAN STATIONS GIVES OCEAN-WIDE COVERAGE OF SHIPPING LANES
LORAN CHART
DEPARTURE AND DESTINATION ARE KNOWN IN EARTH COORDINATES (LATITUDE AND LONGITUDE). DESIRED TRACK IS ESTABLISHED FROM KNOWLEDGE OF DEPARTURE AND DESTINATION IN EARTH COORDINATES.
ACTUAL POSITION OF SHIP CAN BE DETERMINED BY MEANS OF LORAN. LORAN IS A HYPERBOLIC NAVIGATION SYSTEM IN WHICH THE NAVIGATING CRAFT RECEIVES SYNCHRONIZED PULSE SIGNALS FROM AT LEAST THREE KNOWN POINTS. TIME DIFFERENCE BETWEEN ARRIVAL OF SIGNALS FROM ANY PAIR OF THESE TRANSMITTING STATIONS IS MEASURED AND DETERMINES A HYPERBOLA-SHAPED LINE OF POSITION ON A LORAN CHART. BY MEANS OF ANOTHER PAIR OF STATIONS A SECOND SET OF SIGNALS CAN BE USED TO DETERMINE A SECOND LINE OF POSITION. THE CROSSING OF THE TWO LINES OF POSITION GIVES A POSITION FIX IN LORAN COORDINATES.
LORAN CHART SHOWS LORAN LINES OF POSITION SUPERIMPOSED ON GEOGRAPHIC PLOT. THEREFORE, LOCATION OF PRESENT POSITION IN LORAN COORDINATES GIVES DIRECTLY THE LOCATION IN EARTH COORDINATES.

FIG. 5. Navigation by means of loran.

received from any two stations determines a hyperbola-shaped line of position on the navigation chart. Use of at least one other transmitting station determines a second such line of position. The crossing of these two lines of position on the navigation chart establishes a highly accurate fix. With this navigation technique, the difficulties that beset visual observations of landmarks are substantially eliminated. Navigation by such radio-navigation nets, which cover wide areas of the earth's surface, is very useful for locating stationary points and slow-moving vehicles, but is not well adapted to situations that involve rapid maneuvers of fast vehicles.

Radar, which uses wave lengths shorter than those of the radio-navigation systems just described but longer than those of light, gives direct indication of distance from a single landmark. It is an excellent means for navigation by direct-line-of-sight contacts, with the restrictions associated with light substantially eliminated (fig. 6). The landmarks for radar may be ordinary terrain features and artificial objects, such as lighthouses, buoys, or other vehicles. Radar devices usually operate by comparing transmitted and reflected pulses. The time between sending and receiving for a particular pulse gives the distance to the reflecting surface in terms of the velocity of light.

An alternative method of using wave lengths of the radar spectrum for the purposes of navigation is to transmit continuous waves instead of pulses. This technique is particularly useful when the transmitter and reflecting surfaces are moving so rapidly with respect to each other that a measurable shift in frequency between reflected and transmitted waves exists. This frequency shift is a manifestation of the well-understood

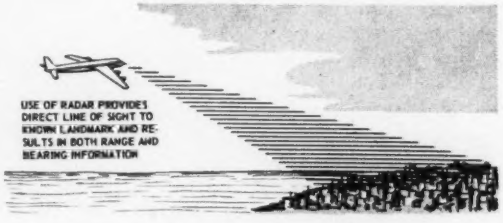

FIG. 6. Navigation by use of radar.

Doppler effect and is the basis for a number of radiation-contact guidance equipments that are classed as Doppler systems.

It is fair to state that toward the middle of the twentieth century, radio and radar methods had substantially eliminated the difficulties that attend the use of visual contacts for the purposes of navigation by terrestrial landmarks. A number of other benefits had also appeared when visible light was replaced by longer wave lengths for navigational purposes: direct range and velocity measurements were available, working distances were greatly extended, direct-line-of-sight restrictions were removed, and complete automation of equipment became feasible. By about 1950, developments of equipment and methods had substantially exhausted the possibilities of improving navigation by terrestrial and celestial references. Improvements in details will always occur, but it is unlikely that these fields will see revolutionary changes in the future.

MODERN PROBLEMS IN NAVIGATION

All the advances in methods, theory, tables, instruments, and techniques that appeared during the course of several thousand years to perfect the art of navigation combined to solve the same problem that confronted the first caveman navigator. This problem was and still is that of finding position on the earth from information provided by time and by radiation contacts with objects having known locations in terrestrial space or celestial space. Navigation progressed with the perfection of chronometers and other instruments, and with improvements in the means for sensing radiation-contact information, until at the present time a state of development exists for these elements that approximates their ultimate possibilities. It now remains for new methods to overcome the problems in navigation that began to emerge during the last half of the fifth decade of our century. These problems, which are not solvable by radiation-contact methods, originated largely from needs associated with modern military operations and flights by vehicles moving in the emptiness of space outside the earth's atmosphere, although civilian applications will surely become important in the future. The new difficulties in navigation appear because the vehicles involved must operate in situations where it is undesirable or impossible to maintain radiation contacts of any kind with outside points.

Bombers flying to attack targets deep within well-defended enemy territory will surely not have an environment of cooperative ground stations and can expect the enemy to take all possible measures for interfering with the operation of such radiation-contact equipments as radios and radars. Submarines designed for the underwater launching of ballistic missiles must have an accurate and continuous knowledge of position during long periods of submerged cruising near enemy shores. Ballistic missiles, which to be effective must be designed for simultaneous launching in salvos of considerable numbers, need to have self-contained guidance systems in order to keep ground installations within feasible limits of size and cost. Satellites, lunar craft, and interplanetary vehicles need navigational equipment designed to make the most effective use of the available weight and volume capacity, so that there are strong reasons for working out designs based on the best possible combinations of radiation-contact components and inertial elements.

These examples serve to illustrate the nature of the new requirements on navigation equipment that have developed during the past ten years. These requirements reduce to the necessity for

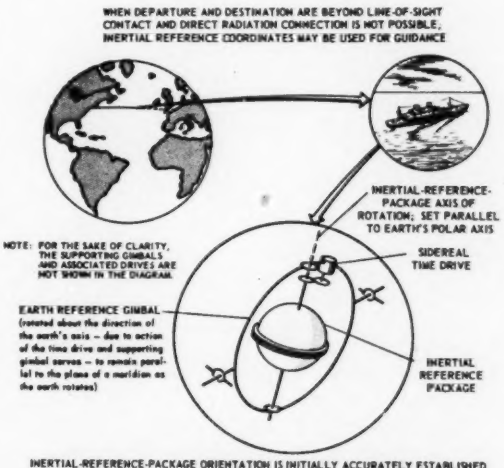
WHEN DEPARTURE AND DESTINATION ARE BEYOND LINE-OF-SIGHT CONTACT AND DIRECT RADIATION CONNECTION IS NOT POSSIBLE, INERTIAL REFERENCE COORDINATES MAY BE USED FOR GUIDANCE
INERTIAL-REFERENCE-PACKAGE AXIS OF ROTATION; SET PARALLEL TO EARTH'S POLAR AXIS
NOTE: FOR THE SAKE OF CLARITY, THE SUPPORTING GIMBALS AND ASSOCIATED DRIVES ARE NOT SHOWN IN THE DIAGRAM.
SIDEREAL TIME DRIVE
EARTH REFERENCE GIMBAL (rotated about the direction of the earth's axis – due to action of the time drive and supporting gimbal servos – to remain parallel to the plane of a meridian as the earth rotates)
INERTIAL REFERENCE PACKAGE
INERTIAL-REFERENCE-PACKAGE ORIENTATION IS INITIALLY ACCURATELY ESTABLISHED WITH RESPECT TO INERTIAL SPACE, THAT IS, WITH RESPECT TO CELESTIAL SPACE (FOR THE PURPOSES OF PRACTICAL GUIDANCE, INERTIAL SPACE AND CELESTIAL SPACE ARE EFFECTIVELY IDENTICAL). THIS MAY INVOLVE THE USE OF DEVICES NOT INCLUDED IN THE INERTIAL GUIDANCE EQUIPMENT.
HIGH-PERFORMANCE INERTIAL-REFERENCE GYRO UNITS (GYRO UNITS WITH LOW DRIFT RATES) SUPPLYING CORRECTION SIGNALS FOR SERVO-DRIVEN GIMBALS OPERATE TO ACCURATELY HOLD THE INERTIAL-REFERENCE-PACKAGE ORIENTATION WITH RESPECT TO INERTIAL SPACE DURING THE PERIOD GUIDANCE IS REQUIRED.
A SPECIFIC FORCE RECEIVER SYSTEM WITH SCHULER TUNING MAY BE USED TO ACCURATELY INDICATE THE VERTICAL IN MOVING VEHICLES.
MEASUREMENT OF THE ANGLES BETWEEN THE VERTICAL AND A MEMBER FIXED WITH THE PROPER ORIENTATION TO THE EARTH REFERENCE GIMBAL GIVES PRESENT POSITION OF THE VEHICLE ON THE EARTH.

FIG. 7. Guidance by substitution of inertial reference coordinates for celestial coordinates.

navigation systems capable of giving high-quality performance during periods that include a considerable number of hours without radiation contacts. In terms of the basic geometry involved, this means that navigation equipment must include a completely self-contained means for providing geometrical references (fig. 7).

Inertial principles applied through the medium of gyroscopic action (see bibliography) make it possible to realize geometrical reference members, in the form of rigid bodies, that are capable of serving the functions of celestial space in navigation. To be satisfactory, these reference members must hold initially established orientations with high accuracy under conditions of operation. The essential features of systems based on reference members of this kind are discussed in the sections that follow.

SELF-CONTAINED GEOMETRICAL REFERENCES FOR NAVIGATION BY APPLICATION OF GYROSCOPIC PRINCIPLES

Gyroscopic effects are mainly associated with the mechanical behavior of a balanced, symmetrical rotor spinning rapidly about its axis of circular symmetry and mounted in gimbals, or carried by some other means, that allow it to have rotational freedom about directions at right angles to its spin axis. The action of such a gyroscope (a name applied by Foucault to devices with the features just described) depends on Newton's law of motion, which states that a particle of mass acted on by a force has a rate of change of its velocity vector in the direction of the applied force. The magnitude of this rate of change is directly proportional to the magnitude of the force and is inversely proportional to the moving mass. Any space in which Newton's law of motion applies is by definition an *inertial space*. The possibility of inertial navigation depends on the fact that matter used for equipment parts responds to applied forces by motions with respect to an inertial space that is essentially identical with the space determined by the fixed stars.

In a moving, rigid body, such as a gyroscopic rotor, interactions among individual particles combine to give the rotor an angular momentum that is equal to the product of the moment of inertia about the spin axis and the angular velocity of spin. The consequence of Newton's law of motion as far as it pertains to a gyroscopic rotor is that a torque applied to the rotor about any axis at right angles to the spin axis causes the spin axis to rotate toward alignment with the torque axis. The angular velocity associated with this rotation, which is called *precession*, is proportional to the magnitude of the applied torque and is inversely proportional to the magnitude of the rotor angular momentum.

When the torque applied to a gyroscopic rotor is zero, the angular velocity of precession is zero, and the spin axis perfectly holds its existing orientation with respect to inertial space. For the purposes of navigation, the important fact is that the space in which a torque-free gyroscopic rotor holds its spin axis in a fixed direction is identical with the celestial space associated with the fixed stars. This means that a geometrical reference member controlled by two or three gyroscopic rotors designed for substantially torque-free operation will hold its orientation almost perfectly with respect to celestial space. Thus, a mechanical member inside a navigation system can supply all the necessary geometrical-reference information, without the need for external radiation contacts of any kind.

In addition to this feature, which supplies the essential need of self-contained navigation equipment, gyroscopic inertial members are more convenient for reference purposes than celestial space, which must be used through the medium of a few nonsystematically located fixed stars. This convenience stems from the fact that torque-free gyroscopic rotors do not tend to move toward any preferred direction, but hold any orientation they may have when applied torques are reduced to zero. Therefore, the orientation chosen for any given situation may be the one that allows the simplest or most convenient configuration of the required mechanism. For example, causing one of the support axes of the gyroscopic package to operate in parrallelism with the earth's axis of rotation makes it possible for a simple sidereal clock drive (such as represented in fig. 7) to compensate for the rotation of the earth. The orientation of the reference member remains fixed with respect to inertial space about this polar axis, so that the first support gimbal outside of the sidereal time drive remains parallel to some meridian on the earth. By mechanical adjustments, this artificial meridian may be aligned with any selected earth meridian. The combination of this artificial meridian inside the navigation equipment and the artificially established direction of the earth's polar axis provides an adjustable earth reference space that is derived from an adjustable inertial reference space and a

time drive. Positions on the earth are fixed by determining the direction of the local gravitational vector with respect to this mechanically established earth reference space (fig. 8).

The inertial-system configuration just described was chosen because of its simplicity for the purposes of explanation. Various other configurations are possible. For example, the gyro units of the inertial reference member may be designed to receive continuous torque inputs that cause the member to change its orientation with respect to inertial space so that it indicates the direction of the local vertical as the system moves over the earth's surface. In a system of this kind, changes in position with respect to the earth are indicated by integrations of torque-controlling signals to calibrated gyro units. Each signal corresponds to an angular velocity component of the reference member with respect to inertial space, and one integration gives the associated angular displacement. Correction of this displacement for rotation of the earth by a time signal and multiplication by the radius of the earth gives a component of distance traveled over the earth's surface. The same procedure applied to the other components of inertial-reference-member rotation gives the corresponding components of travel. Combining all the travel components gives the indicated resultant movement of an inertial navigation system over the earth. Relating this indicated movement to the point of departure gives the indicated position of the vehicle carrying the navigation equipment at any instant.

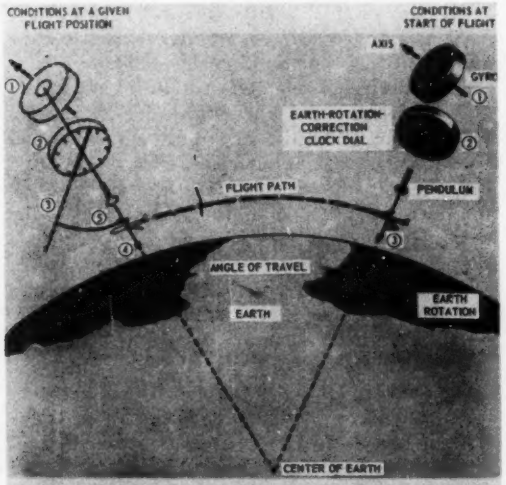
CONDITIONS AT A GIVEN FLIGHT POSITION
CONDITIONS AT START OF FLIGHT
AXIS
GYRO
EARTH-ROTATION-CORRECTION CLOCK DIAL
FLIGHT PATH
PENDULUM
ANGLE OF TRAVEL
EARTH
EARTH ROTATION
CENTER OF EARTH
① GYRO HOLDS AXIS DIRECTION CONSTANT WITH RESPECT TO FIXED STARS, THAT IS, WITH RESPECT TO AN INERTIAL REFERENCE SPACE.
② DIAL ROTATION WITH SIDEREAL TIME CORRECTS FOR EARTH ROTATION TO GIVE AN EARTH REFERENCE SPACE.
③ DIRECTION OF GRAVITY AT START OF FLIGHT, WITH RESPECT TO THE EARTH REFERENCE SPACE.
④ DIRECTION OF GRAVITY AT FLIGHT POSITION REPRESENTED BY DOTTED LINES, WITH RESPECT TO THE EARTH REFERENCE SPACE.
⑤ INDICATED ANGLE OF TRAVEL IS PROVIDED BY ANGULAR DISPLACEMENT, IN EARTH REFERENCE SPACE, OF DIRECTION OF GRAVITY WITH RESPECT TO ITS POSITION AT THE START OF THE FLIGHT.

FIG. 8. Inertial system simplified to illustrate elements of navigation for vehicles moving at substantially constant altitude.

Another configuration of inertial navigation equipment places the inertial reference member in an arbitrary orientation and employs computers to produce information on indicated position. This arrangement is often used for the guidance of ballistic missiles.

PRACTICAL ASPECTS OF INERTIAL REFERENCES

In practice, inertial references involve many factors that cannot be mentioned in this paper because of space limitations. Some of these factors are associated with design details, while others are common to all systems. One of these common factors is the necessity for establishing the desired inertial-reference-member orientation prior to any period of use for the system containing the member. This orientation must be based on inputs generated by means outside the gyro units of the reference member and supplied to these units as angular-velocity command signals that become zero when the proper orientation is reached. For example, an optical system using a light-sensitive cell tracker pointed toward Polaris and a servomechanism arrangement can be used to drive an axis of the inertial reference member toward alignment with the earth's axis of rotation. Similarly, pendulum signals can be used for properly setting the reference member in a selected angular position about the polar axis.

Any actual gyro unit is imperfect in the sense that its rotor can never be completely torque-free, with the result that the spin axis does not hold its direction perfectly with respect to inertial space. However, by proper design and construction, it is possible to make the resultant of undesired torque components very small and to keep the uncertainty parts of these components at still lower levels. Drift rates having an order of magnitude of one one-thousandth of earth's rate (earth's rate is fifteen degrees per hour) can now be expected from commercially available gyro units. For high performance, the rotors of

these units cannot be used directly to generate motion-resisting torques sufficient to control heavy supporting gimbals. However, techniques are available that make it feasible for the member carrying the spin-axis bearings of the rotor to operate under conditions of substantially complete freedom from interfering torque components. In units that take advantage of this possibility, deflections of the case of the unit with respect to the rotor are not used to provide "brute force" torques but are used only for the generation of control signals, a service that imposes virtually zero torque loads. By using these signals as command inputs to amplifiers controlling the servomotors that drive the supporting gimbals, the effects of friction and other disturbing torques may be overcome so completely that the structure carrying the gyro units holds accurately an orientation determined by the gyro spin axes.

SPECIFIC-FORCE-RECEIVER SYSTEMS FOR INDICATIONS OF THE VERTICAL AND THE DISTANCE TRAVELED

Inertial navigation systems designed to operate on or near the earth's surface must have some provision for indicating the direction of the local vertical. This direction gives indicated position through its orientation with respect to the artificially established earth coordinate reference of the system. On a platform fixed to the earth, the problem of indicating the vertical is easily solved by means of a simple pendulum. On a moving platform subjected to horizontal accelerations, a simple pendulum is no longer satisfactory, because of interfering effects introduced by these accelerations. This interference is unavoidable because, by Einstein's principle of equivalence, the mass of any body in its response to a gravitational field is identical with the mass associated with inertia-reaction effects. Thus, a pendulum bob hanging along the vertical under gravity is deflected when its point of support is given any horizontal acceleration. Under the accelerations usually experienced by moving vehicles, a simple pendulum may well have erratic deflections of several degrees. Disturbances of this magnitude are completely unacceptable for the purposes of navigation where the required maximum accuracy magnitude is of the order of one mile. When it is remembered that on the earth's surface one minute of arc between local-vertical directions corresponds to a distance of one nautical mile, the uselessness of simple pendulum arrangements for navigation is apparent.

Errors in local-vertical indications under conditions of erratic acceleration of a moving vehicle may be reduced to satisfactory limits by designing the indicating system so that it has a proper dynamic behavior. The required characteristic is that of responding to a horizontal linear acceleration component by an angular acceleration about a horizontal axis at right angles to the linear acceleration. When the angular acceleration has a magnitude equal to the linear horizontal acceleration divided by the radius from the center of the earth to the moving platform, vertical indications change in step with variations in position. A system with performance of this kind is said to have Schuler tuning; this is in recognition of Professor Schuler, who first published the theory of such arrangements. When Schuler tuning is used, indications of the vertical remain accurate in the presence of arbitrary horizontal accelerations. On the surface of the earth, Schuler tuning corresponds to a period of about eighty-four minutes. Any practical system possessing the features suggested in figure 8 would have to use a pendulum with this characteristic.

Because of the small distance between the pivot and the center of gravity that would be required in a simple physical pendulum with Schuler tuning, a pendulum of this kind is not physically feasible. The practical solution for this problem is to use an equivalent pendulum system based on a servodriven gimbal-supported platform carrying sensing elements that respond to gravity and acceleration. Amplifiers in the feedback loops are designed so that electronic circuits act to introduce the required dynamic performance. By variation of circuit parameters, it is possible to adjust both the period and the damping so that optimum results are achieved under operating conditions.

The sensing components required for Schuler-tuned equivalent pendulum systems are arrangements in which gravitational and inertia-reaction forces acting on a seismic mass (a body designed to act as the receiving element for the sensors) cause deflections against some restraining means in a way that generates an output signal representing the resultant input force. This resultant is made up of the force acting to move the seismic element in the direction of the gravity field and the inertia-reaction effects that tend to cause the seismic element to lag behind the linear acceleration of the sensing unit. It is convenient to consider gravity and inertia-reaction

effects as combining to form the *specific force*, which is the resultant force per unit mass acting on a body due to gravity and acceleration. A simple pendulum is a specific-force receiver in which the suspended mass tends to align itself with the direction of the specific-force input vector. Many other kinds of specific-force receivers are in use in which the output signal represents the specific-force component acting along an input axis that has a fixed direction with respect to the case of the sensing component. Devices of this kind appear as essential elements in all inertial navigation systems.

INERTIAL NAVIGATION SYSTEMS FOR VEHICLES MOVING AT SUBSTANTIALLY CONSTANT ALTITUDE

Navigation systems used in vehicles supported by ground, air, or water normally move in surfaces that are substantially spherical about the center of the earth, so that the specific-force input for specific-force receivers is practically identical with gravity. This means that it is feasible to indicate the direction of gravity by means of an equivalent pendulum system with Schuler tuning. Inertial equipments for use in ground vehicles, aircraft, surface ships, and submarines all take advantage of this fact by basing their indications of vehicle location on the orientation of an indicated vertical member with respect to an earth reference member positioned by a gyroscopic inertial reference system and sidereal time. In some cases, the inertial reference member holds its physical orientation among the stars, while in other cases the member moves, and its rate of change of orientation with respect to inertial space acts as the input for a computer whose output is navigational information.

Many designs are possible for inertial systems based on indications of the local vertical by an equivalent pendulum with Schuler tuning. Several different equipments have been constructed by various commercial organizations and tested far enough to prove the feasibility of inertial navigation, but it is to be expected that several years of effort will have to pass before final decisions as to the best type of equipment can be made.

INERTIAL GUIDANCE SYSTEMS FOR BALLISTIC MISSILES AND SATELLITES

Ballistic missiles are subjected to high accelerations for short periods of high thrust during the phase of boosting through the atmosphere and then coast in free fall until they re-enter the air before striking target areas. In this situation, it is not feasible to base guidance on indications of the local vertical. During the boost phase, the inputs for specific-force receivers are greatly different from gravity, both in direction and in magnitude. During the coasting phase, free fall reduces the net specific force to zero, so there are effectively no inputs for specific-force receivers. Re-entry and the terminal phase are again subject to accelerations due to air resistance that cause the specific force available as the input for guidance equipment to be greatly different from gravity. These facts combine to prevent systems that operate by indicating the local direction of gravity from being useful in

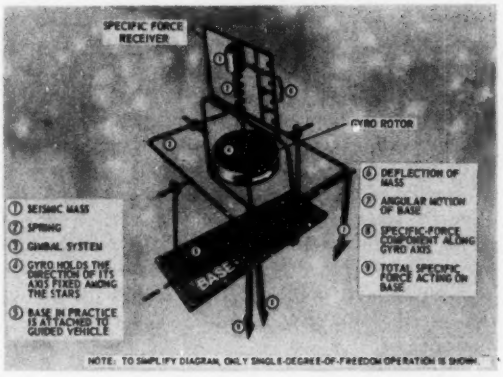
SPECIFIC FORCE RECEIVER
GYRO ROTOR
BASE
1 SEISMIC MASS
2 SPRING
3 GIMBAL SYSTEM
4 GYRO HOLDS THE DIRECTION OF ITS AXIS FIXED AMONG THE STARS
5 BASE IN PRACTICE IS ATTACHED TO GUIDED VEHICLE
6 DEFLECTION OF MASS
7 ANGULAR MOTION OF BASE
8 SPECIFIC-FORCE COMPONENT ALONG GYRO AXIS
9 TOTAL SPECIFIC FORCE ACTING ON BASE
NOTE: TO SIMPLIFY DIAGRAM, ONLY SINGLE-DEGREE-OF-FREEDOM OPERATION IS SHOWN

FIG. 9. Two-degree-of-freedom gyro and single-degree-of-freedom specific force receiver illustrating elements of inertial guidance for vehicles in arbitrary motion with respect to the earth.

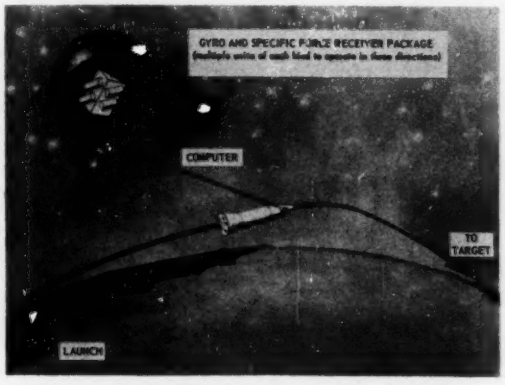

FIG. 10. Inertial guidance for a ballistic missile.

equipment for guiding ballistic missiles. Some other mode of operation must therefore be used to meet the operating requirements of such equipment.

Inertial guidance for ballistic missiles is achieved by eliminating terrestrial-space reference equipment and solving the guidance problem by means of specific-force receivers fixed in an artificially oriented space that is associated with a gyroscopic reference member (fig. 9). To mechanize this arrangement, a rigid body member supported by a servodriven gimbal system carries the necessary gyro units and, in addition, serves as the mounting for a set of three single-degree-of-freedom specific-force receivers with their input axes set at right angles to each other (fig. 10). With this configuration, the total specific force acting on the gyro-oriented reference member is sensed in three components in a special set of coordinates having known geometrical relationships to terrestrial space and to celestial space. Signals representing these components are generated by the specific-force sensors and transmitted to a computer. This computer, acting on these inputs and on information stored in its memory banks, works out the instantaneous location of the missile under guidance, compares this location with the desired location on the proper path, and generates command signals for correcting the direction of the missile. These command signals are received by the missile control system, which changes the orientation of the thrust vector with respect to the missile so that the necessary changes in the missile path are made.

Ballistic-missile guidance is carried out in artificially established inertial-space coordinates, with the target considered as a moving point because of the earth's rotation. For the purposes of this guidance method, gravity is regarded as merely one component of the resultant specific force, without any particular attention to its direction as it is related to location on the earth. Time is also an input to the system, but it is one of several factors for the computer, rather than the means for determining the orientation of the earth.

Satellites may be put into orbit by inertial guidance, but inertial equipment is not particularly required during long periods of coasting flight. Very probably, inertial devices will be useful in sensing angular-velocity inputs for control purposes. It is also likely that gyroscopic stabilization will be utilized to assist radiation-contact devices within satellites in tracking the earth and other celestial bodies.

INTERPLANETARY GUIDANCE

Interplanetary vehicles must operate for long periods of time with only tenuous radiation contacts with either their points of departure or their destinations. During the midcourse phases of long interplanetary trips, it may be desirable for the guided vehicle and its equipment to be able to operate without outside assistance from manned installations. Conditions will be close to ideal for radiation contacts with celestial bodies, and techniques are well developed for acquiring and tracking sources of optical wave lengths. Data from the operation of optical trackers, com-

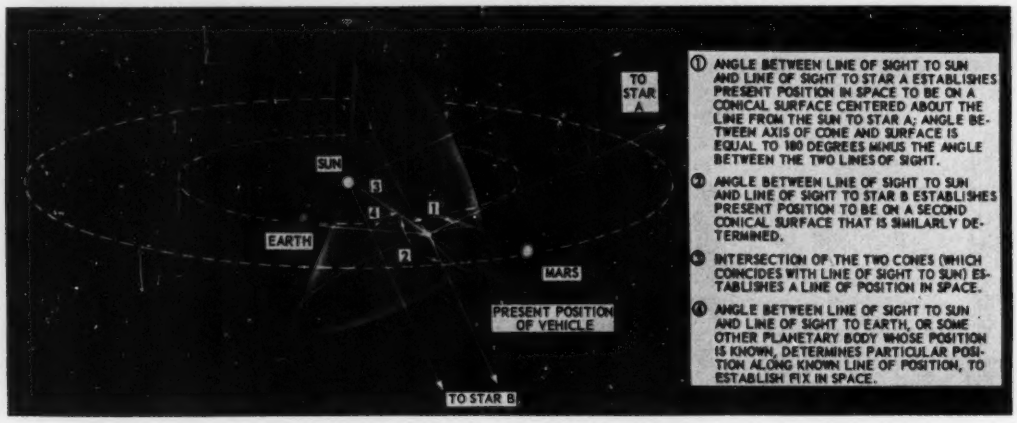
TO STAR A
SUN
EARTH
MARS
PRESENT POSITION OF VEHICLE
TO STAR B
1 ANGLE BETWEEN LINE OF SIGHT TO SUN AND LINE OF SIGHT TO STAR A ESTABLISHES PRESENT POSITION IN SPACE TO BE ON A CONICAL SURFACE CENTERED ABOUT THE LINE FROM THE SUN TO STAR A; ANGLE BETWEEN AXIS OF CONE AND SURFACE IS EQUAL TO 180 DEGREES MINUS THE ANGLE BETWEEN THE TWO LINES OF SIGHT.
2 ANGLE BETWEEN LINE OF SIGHT TO SUN AND LINE OF SIGHT TO STAR B ESTABLISHES PRESENT POSITION TO BE ON A SECOND CONICAL SURFACE THAT IS SIMILARLY DETERMINED.
3 INTERSECTION OF THE TWO CONES (WHICH COINCIDES WITH LINE OF SIGHT TO SUN) ESTABLISHES A LINE OF POSITION IN SPACE.
4 ANGLE BETWEEN LINE OF SIGHT TO SUN AND LINE OF SIGHT TO EARTH, OR SOME OTHER PLANETARY BODY WHOSE POSITION IS KNOWN, DETERMINES PARTICULAR POSITION ALONG KNOWN LINE OF POSITION, TO ESTABLISH FIX IN SPACE.

FIG. 11. The geometry of a fix in space.

bined with accurate time from devices based on the natural-frequency vibrations of atoms or elastic bodies and with almanac data stored in digital computer memories, provide all the information needed for the accurate navigation of space vehicles. In effect, celestial-space coordinates are used for this purpose, with locations of the guided vehicle determined from the angular relationships among lines of sight to the sun, the stars, the observable planets, and satellites such as the moon. These lines of sight can be automatically sought out by optical trackers and may be maintained either by continuous tracking or by the use of gyroscopically controlled reference members with their orientations set from radiation-contact information.

For example, the process of navigation might start by acquiring and maintaining the line of sight from the vehicle to the sun by means of a heliotracker (fig. 11). The second step would be searching for a selected star over a conical surface about the heliocentric line by means of a star tracker whose angle setting is based on an accurate indication of time and data stored in the memory of a computer. The angle measured between the lines of sight to the sun and this star establishes in celestial coordinates one of the cones of position shown in figure 11. This process is repeated with a second star. Then the angle between the sun line of sight and a planet line of sight is used to determine the location of the vehicle along the line of intersection of the two cones.

CONCLUSION

Navigation has been discussed in general terms, with emphasis on the geometrical aspects of the problems involved. Radiation contacts with terrestrial and celestial points provide means for navigation under ordinary circumstances. In the special situations that arise when radiation contacts are not feasible, inertial methods are available. Practical applications of these methods are too new for details of equipments to be settled, but it is certain that navigation of the future will employ many different arrangements, ranging from all-radiation-contact systems to all-inertial systems with various compromise arrangements in between. We can look forward with confidence to rapid and interesting developments in the old art of navigation.

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CASTE AND THE EVOLUTION OF THE INDUSTRIAL WORKFORCE IN INDIA[1]

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I

DESPITE the ubiquity of caste and the intense interest the phenomenon has generated among scholars, virtually no attention has been paid to the relationship of caste to the process of industrialization in India. Certain generalizations have been made about the caste groups that flow into industry, about the impact of industrial employment on caste coherence and about the caste composition of industrial entrepreneurship. Although some widely-held notions exist, it is rather startling to discover that these conclusions have no detailed empirical support whatever. It is possible, of course, that these propositions, even in the absence of detailed investigation, are correct. Unfortunately, because many of these ideas are mutually contradictory, it is impossible to decide which propositions possess the aroma of truth.

The uncertainty of traditional judgments was pressed upon me in the course of studies I have been pursuing on the recruitment and disciplining of an industrial labor force. In studying the economic history of industrial workforce mobilization, it was inevitably tempting to consider the influence of caste on that process and the impact of industrial employment on caste. Specifically concerned with the cotton textile industry of Bombay City and the iron and steel industry of Jamshedpur, I discovered that the vast official literature—going back to the 1870's in the case of the cotton industry and to the first decade of this century in the case of the iron and steel industry—contains no significant references to the phenomenon. Except for some casual references, the institution of caste is wholly ignored.[2]

Nor have scholars done much better. Until recently, those who preempted the study of the institution were preoccupied with a static, functional analysis of caste in the village. Even now, the study of the dynamics of caste relations still retains an essentially rural focus. To the extent that anthropologists and sociologists have in the past few years turned their attention to the nature of caste dynamics outside the village, almost the entire interest has been in the impact of urbanization on caste patterns of behavior. Unfortunately, the effects of urbanization are not necessarily the same as the effects of the industrial environment.[3] Nor do such preoccupations necessarily tell us anything about the behavior of an industrial labor force. Therefore, it is appropriate to say that recent investigations have left us little better off than we were a generation or more ago.[4] In

[1] This essay was presented to a session of the 11th Annual Meeting of the Association for Asian Studies, Washington, D. C., March, 1959. The research from which it derives was made possible by a grant from the Penrose Fund of the American Philosophical Society supplementing a Ford Foundation Area Training Fellowship, 1956–1957. I am grateful for the aid of Dr. Ram Raj Prasad Singh and for the patience of colleagues in India and in this country with whom these issues were in one way or another discussed. Dr. R. D. Lambert, particularly, has tried his best to sharpen and improve the analysis. The Tata Iron and Steel Company very generously made certain materials available to me.

[2] There are innumerable official investigations of the conditions of industrial wage workers in India going back to 1874. The most important survey was that of the Royal Commission on Labour in India, *Report of the Royal Commission on Labour in India*, 19 v., London, His Majesty's Stationery Office, 1931. (Subsequent references to this investigation will be identified as RCL.)

[3] Hoselitz, Bert F., The city, the factory, and economic growth, *Amer. Econ. Rev.* **45**: 166–184, May, 1955. After completing this paper, I came on an essay by the distinguished Indian anthropologist, M. N. Srinivas. In this essay Srinivas not only agrees that "next to nothing is known about the social background of industrial workers in different parts of India," but he goes further and states that even information on the functioning of caste in the urban setting "is conspicuous by its absence." Srinivas, M. N., Social anthropology and the study of rural and urban societies, *The Economic Weekly* (Bombay) **11**: 137, 1959. (*The Economic Weekly* will henceforth be referred to as *EW*.)

[4] Lambert, R. D., Factory workers and the non-factory population in Poona, *Jour. Asian Studies* **18**: 21–42, 1958, provides perhaps the only piece of significant scholarship directly related to the issues with which this essay is concerned. Lambert's analysis, however, is based on the statistics of a moment in time and therefore throws no direct light on the dynamics of caste in industrial situations. To the extent that his study comes to grips with this issue, Lambert's conclusions generally confirm the results of my own investigations. Para-

one way, moreover, we are probably worse off. Since Independence there has been strong official pressure to cease collecting caste information, so that to the extent that one is fortunate enough to get access to business records for the period after 1947 it is likely that they will be of little assistance.[5]

While my own work has brought me up against the problem of caste as it bears on the early stages of industrial labor force recruitment and disciplining, my professional expertise and interests have kept me away from direct investigation of the issue. Nevertheless, it is difficult to comprehend why, if the caste system is as vigorous, all-pervasive, and influential as we are told,[6] business and government materials have revealed so profound a lack of concern with the issue of caste in the factories, and why there has been so little evidence of caste among workers during strikes and in the operation of trade unions. Having had to reject most of the available literature as completely unsatisfactory, I have been forced to think about the problems that must be faced before adequate answers can be forthcoming to my problems.

This paper provides no new information and no bold new hypotheses. Rather it contains a description of the problems I have faced in my work and suggests the kind of investigations that are needed before we can say very much about the way caste relationships influenced the mobilization of a labor force for the modern factory system and the influences the factory system has had upon the structure and functioning of caste. If I am able to indicate the complex possibilities and the true ignorance by which we are surrounded, it may be possible to stem the tide of hasty generalization that has made it so difficult to explain the character of industrial labor force origins and behavior. This paper will not attempt to deal with all facets of the problem nor will it attempt to explore all the difficulties inherent in the ones that are discussed. It proposes to discuss (1) the character of the population that migrated; (2) the extent to which caste influenced factory occupation, either by choice of the worker or selection by the employer; and (3) the degree to which caste affected the character of worker cooperation against employers. The comments must be restricted to the modern industrial sector and what evidence is used derives mainly from the Bombay cotton textile and Jamshedpur iron and steel industries.

II

When we speak of the recruitment of the labor force for modern factory industry in India, the first issue to consider is the character of the population that migrates from rural areas to seek industrial employment. It is typically assumed that rural migrants to urban areas are in the main the economically depressed and also, although this is not always explicitly stated, that these people are also the socially depressed.[7] It is probable that the majority of those who seek industrial employment are economically depressed in the rural areas, but even this seemingly obvious proposition is not completely clear. The term "economically depressed" applies to so large a proportion of the Indian population that small differences take on great significance. Apart from the fact that not all migration is distress migration, we know that even in India movement is not cost-free. It is therefore possible that only those who can afford to move actually do migrate. Therefore, we cannot be absolutely certain that it is the very lowest income stratum that moves.[8]

thasarathy, V. S., Caste in a south Indian textile mill, *EW* **10**: 1083–1086, 1958, discusses the dynamics of caste in a specific industrial situation, but the analysis is so general as to vitiate its usefulness.

[5] For example, in 1940 the Bombay Millowners' Association conducted a survey of the cotton mill workforce which included a tabulation of the workforce by caste affiliation. However, in a similar survey conducted in 1955 the caste tabulation was not made. *Cf.* Gokhale, R. G., *The Bombay cotton mill worker*, Bombay, The Millowners' Association, 1957. The 1940 caste tabulation will be found, *ibid.*, 116. The Government of India has tended to oppose the collection of caste data because such investigations tend to encourage the divisive influence of "caste patriotism." On this point, *cf.* Ghurye, G. S., *Caste and class in India*, 169ff., Bombay, Popular Book Depot, 1950. But official policy has been contradictory. While on one hand, collection of caste data has been opposed, on the other, it has been found necessary to collect some information in order to guarantee effective administration of the policy of granting special advantages to scheduled caste and tribal groups.

[6] "Caste is so tacitly and so completely accepted by all, including those who are most vocal in condemning it, that it is everywhere the unit of social action." Srinivas, M. N., Caste in modern India, *Jour. Asian Studies* **16**: 548, 1957.

[7] RCL, *Report*, 14–15; Buchanan, D. H., *The development of capitalist enterprise in India*, 294–300, New York, Macmillan, 1934; Jathar, G. B., and S. G. Beri, *Indian economics* **2**: 64–65, London, Oxford University Press, 1949.

[8] In fact, some recent scholarship suggests that it is frequently the economically better-off groups that migrate. Eames, E., Some aspects of urban migration from a village in north central India, *Eastern Anthropologist*

The traditional view holds that rural migrants are not only the economically most depressed but that they also constitute the socially most depressed groups. In other words, it is assumed that there has been a disproportionately large rural outflow of low-caste people, most specifically of various untouchable groups.[9] Apart from the assumed direct association of low economic and social status in the migrants from the rural sector, it is also suggested that the more or less generalized spread of ideas of social betterment has encouraged depressed caste groups to flee to urban areas.[10]

Unfortunately, there is no definite confirmation of either of these propositions. While there have been village studies that give us evidence that caste status and income are somewhat correlated, there is no evidence to my knowledge that will show us that the migration out of rural areas is disproportionately high for special castes. While it is certainly true that low-castes together with untouchables constitute an overwhelmingly large proportion of migrants to urban areas, on the face of it this is merely the result of the fact that God has put so many Indians into these categories in the rural sector. Certainly, before we make bold statements about the caste groups that migrate out of rural areas, some detailed investigations have to be carried out.

For example, it is sometimes stated that untouchable caste groups moved to industrializing centers first and the higher castes move in later.[11] The Jamshedpur and Bombay evidence controverts this. It is also suggested that the influx of untouchables was disproportionately high.[12] Even this proposition is hard to sustain. Bombay in 1864, following a prolonged and massive influx associated with special economic factors, had a population of 816,000, less than 4 per cent of which were untouchables. While the percentage of untouchables gradually rose, even as late as 1921 it was not much more than 10 per cent of the total population and after that date the proportion began to decline steadily. It was only in the period 1901–1921 that the proportion of untouchables in the Bombay City population rose above the 6–7 per cent ratio that untouchables constituted in the population of Bombay Presidency.[13]

Ignoring the unreliability of the census caste data, let us admit for the moment that they suggest that the rate of increase of untouchables in the Bombay City population was greater than that of other groups, at least until 1921.[14] Nevertheless, there are certain specific weaknesses which make it impossible to use the census data to prove that untouchables have shown a greater tendency to migrate to the city than other groups. Not only are there difficulties associated with birthplace data, but the census returns do not tell us anything about caste group fertility. It is therefore impossible to determine whether the differential rates of increase of various caste groups in Bombay City are a function of migration or of the birthrates in the city itself. This is an important problem in this context inasmuch as Davis tells us that fertility tends to be inversely related with social (i.e., caste) status.[15] Moreover, even if we were certain that the differential caste group increases were due entirely to migration from rural areas, we could not be certain that the enhancement of the proportion of any specific caste groups was the result of special pressures in the countryside on these social groups. Changing caste proportions over time in Bombay City might well have been a function of shifts in the districts from which migration occurred and the different caste compositions in these various districts. Until there are studies which relate caste composition of migrants to the towns to the caste composition of the cohort populations

8: 13–14, 1954; Mukherjee, Amar, Socioeconomic survey of some Bengal villages, *EW* **6**: 1907, 1954. There are also certain suggestive references in three studies contained in *India's villages*, 36, 91, 165, Calcutta, Development Department, West Bengal Government, 1955.

[9] Knowles, L. C. A., *The economic development of the British empire*, 238, New York, A. & C. Boni, 1925; Rao, B. Shiva, Labor in India, *Annals, Amer. Acad. Pol. and Soc. Sci.* **233**: 128, 1944; RCL *Report*, 14–15; Buchanan, *op. cit.*, 294–300.

[10] The classic statement is found in RCL, *Report*, 15–16.

[11] Myers, Charles A., *Labor problems in the industrialization of India*, 40, Cambridge, Harvard University Press, 1958.

[12] Mukerjee, Radhakamal, *The Indian working class*, 6, 3rd ed., Bombay, Hind Kitabs, 1951.

[13] Based on data taken from the various censuses for Bombay City and Bombay Presidency. This evidence, of course, describes the flow of people into the city generally rather than into industry specifically. However, it is necessary to clear away some general issues before touching directly on the industrialization problem.

[14] On the serious weaknesses of census caste data, *cf.*, the comments of R. E. Enthoven, Superintendent of the Bombay Ethnographic Survey, as quoted and reiterated by J. L. Sedgwick, Superintendent of Census Operations, in *Census of India 1921* **8** (1): 178, Bombay, Government Central Press, 1922.

[15] Davis, Kingsley, *The population of India and Pakistan*, 73–74, Princeton, Princeton University Press, 1951.

from which they have been derived, it is completely inappropriate to make any generalizations of the sort that have been so common.

III

The next issue that must be considered is the extent to which caste influences industrial occupation. There is a general tendency to argue that industry is caste-blind for a host of reasons, some or all of which are relevant to any industrial situation of consequence. It may be because of the inadequate supply of labor from any single caste, because of the inability to determine specific caste affiliation in an industrial situation, because of the lack of employer concern with the phenomenon or because of the willingness of all castes to do all work. It is typically suggested that given such caste blindness and the consequential mixing of industrial workers in factories, the caste system will ultimately be undermined. An extreme version of this theme has been advanced by Kingsley Davis: "If industrialism proceeds rapidly [in India] . . . the caste system will have essentially disappeared by the end of this century." [16]

While such propositions suggest something, right or wrong, about the ultimate impact of factory employment, they tell us nothing about caste groups as they do exist in industry. In fact, such propositions tend to evade the very important problem of the degree to which caste affiliation has tended to determine the general chances of being hired in industrial establishments and the specific jobs for which hiring will be done. We want to know whether the social attitudes of the available workforce require it to be job-selective in some pattern of caste preference. We also want to know whether the social attitudes of employers and their agents lead to some pattern of caste selection for factory employment in general or for certain specific occupations. But before we can get any analysis of social attitudes that might lead to caste clustering, we require objective data, statistical evidence on the extent to which caste clustering can be found in industry.

(1) In any single industrial center, is there a tendency for individual castes to cluster in individual industries? If so, is the pattern the same in every industrial center where such industries appear?

(2) Whether or not there is a pattern of caste concentration by industry, do specific castes cluster into individual factories?

(3) Do specific castes tend to cluster in individual departments of an industry, and if so, does this occur in individual firms or in all factories of the industry?

(4) If specific castes are clustered in specific departments, do they dominate all jobs in the department, or are there tendencies for them to be restricted to specific skilled or unskilled classifications?

Once we have indicated the questions to which we need to have answers in order to determine the extent of caste clustering in factories, it will be very clear to anyone familiar with the monographic literature how little we know about caste composition of the industrial workforce. And without this evidence any attempt to discuss the dynamics of caste and industrialization must prove futile.

Some scholars who have written about the character of the industrial workforce have suggested that industrial workers, certainly in the unskilled and semi-skilled categories that constitute the bulk of jobs in Indian industry, are mainly untouchables.[17] More generally, the tendency is to claim only that factory workers have been drawn from low-caste groups, both touchable and untouchable.[18] On the other hand, at least one commentator has gone to quite the other extreme and advanced the proposition that factory workers "never belonged to the secluded castes. . . ." [19] Ignoring the contradictory character of these generalizations, there has been a tendency to suggest that there was and is a pattern of caste clustering by occupation.[20] But the data provided by authorities in the field is of such questionable reliability that it is difficult to know whether we have any information at all. There has, in fact, been a systematic confusion of caste

[16] *Ibid.*, 176.

[17] Buchanan, *op. cit.*, 296–297 and the literacy data at 405; Knowles, *op. cit.*, 283; and Mukerjee, R., *op. cit.*, 6 and 8–9.

[18] Myers, *op. cit.*, 38.

[19] Gray, H., The progress of women, in *Modern India and the West*, 447, edited by L. S. S. O'Malley, London, Oxford University Press, 1941.

[20] Mehta, S. D., *The cotton mills of India 1854–1954*, 121, Bombay, The Textile Association, 1954; Prasad, Narmadeshwan, *The myth of the caste system*, 122, Patna, Samjna Prakashan, 1957; and Mukerjee, R., *op. cit.*, 8–9.

with village, region, language, occupation, and religion.

Despite these strictures, there is one study on which great reliance has been placed. This is the 1940 survey of 37,600 employees, some 25 per cent of the workforce of the Bombay City cotton textile industry, published by the Bombay Millowners' Association. This survey indicated that 13.8 per cent of the industry's labor force was drawn from Harijan (untouchable) groups, nearly double the proportion of untouchables in the city population. It also showed that these groups tended to be concentrated in certain departments of the industry, 70 per cent of male Harijans being employed in ring spinning (where they constituted 40.8 per cent of the workers) and 73 per cent of female Harijans being employed in the winding and reeling departments (where they comprised 20.9 per cent of the workforce.) Virtually no Harijans were employed in the weaving sheds.[21]

At this point I must digress and indicate that for the purpose of this paper it is not necessary to establish a precise definition of caste. Nevertheless, it is important to note that I am using the term to refer to what are now more carefully called sub-castes (*jati*), endogamous groups with individual existence in territorially confined areas of the countryside. It is entirely inappropriate to lump into larger groups because of similarity of name or function sub-castes that are not endogamous.[22] For any analysis of labor force recruitment and the study of its behavior in the industrial environment, we must begin our study with those social units which have homogeneity and cohesive behavior in the countryside.

I am not necessarily arguing that village sub-caste (*jati*) relationships will ultimately be the most relevant categories of social behavior of the workforce inside the factory system. In fact, as will be indicated later, I incline to the view that *jati* relationships ultimately are irrelevant in the factory. But when one is concerned with the historical process of creating an industrial labor force, analysis must begin with the existing social relationships in the villages from which the workforce comes. This is absolutely necessary when the specific problem is the role of caste in influencing the process of recruitment and disciplining of the rural migrants to urban-industrial employments. If these social groupings, so crucial in the villages, cease to have relevance or develop a changed character in the factory environment, this does not reduce the original significance of the *jati* as a category for the problems with which we are here concerned. It is precisely the phenomenon of transformation from *jati* to something else that becomes critical for us to describe and evaluate. But scholarship has certainly not as yet got this far. The current difficulty is that investigators have tended to use the concept caste (or sub-caste or *jati*) to mean one thing in the description of village social structure and something quite different, and confusing, in the description of industrial socio-economic structure.[23]

Viewed with these necessary characteristics in mind, any attempt to use the 1940 Millowners' Association caste data reveals their deficiencies. Apart from serious questions about the quality of the sample, the caste categories are far too general to be at all useful. Among the six "caste" categories used were Kunbi, Maratha, Bhayya, and Harijan. Neither Kunbis nor Marathas are single interdining, intermarrying groups. Both are clusters of endogamous groups. Moreover, Kunbis of various sorts have gradually hidden themselves within the Maratha classification.[24] Bhayya is not a caste designation at all but a regional term referring to all groups from the United Provinces. Harijan, of course, is a euphemism that comprehends all depressed castes. In Bombay this term includes five major groups —Dheds, Mahars, Chambhars, Mochis, and Mangs —and a number of minor ones. Inasmuch as these groups are mutually exclusive in the countryside, it is inappropriate to lump them all together. An illustration of this point was related by T. W. Johnstone, Chief Inspector of Factories for Bombay Presidency.

> Some years ago in Ahmedabad I happened to visit a mill and I found about 70 or 80 people fighting with the rods they use in the blow rooms; half a dozen of them were laid out. They were all low caste untouchable people, *wagris* and *dheds*. The trouble arose through a *wagri* touching a *dhed's* food.[25]

In other words, these conglomerate categories are hard to justify when the crux of the issue is not only the functioning distinctiveness of the groups who become part of the industrial labor force but

[21] Gokhale, *op. cit.*, 116, table A-II.

[22] Karve, Irawati, What is caste? *EW* **10**: 125–138, 1958.

[23] Srinivas, M. N., Village studies and their significance, *Eastern Anthropologist* **8**: 223–225, 1955, suggests that the confusion exists in village studies as well.

[24] Karve, *op. cit.*

[25] RCL, *Evidence* **1** (2): 241, answer A-3945.

also the possible effects of such exclusiveness inside the factory system.[26]

In effect, the 1940 Bombay Millowners' Association survey merely tells us that in the weaving sheds there were no untouchable groups.[27] But we do not know whether or not, apart from this limitation, there is any pattern of caste concentration in this department. Nor does Lambert's recent study of five Poona factories help much. Certain caste concentrations manifest themselves, but only as among the five units. His report does not provide clear evidence about caste grouping departmentally within the individual factories.[28]

There is one other source of data available. On at least one occasion after World War II, the Tata Iron and Steel Company at Jamshedpur had occasion to require data on opportunities available to scheduled castes and tribal groups. In compiling these data in 1951, the caste designation of each person employed was noted on the wage sheets for every department. Unfortunately the Company's needs were general, and the detailed caste information was not compiled. Even more unfortunate is the fact that the departmental wage sheets which contained the caste notations were largely destroyed. Only the sheets for a few departments survived the Company's generous impulse to turn over the vast bulk of its old Jamshedpur records to a local scrap paper drive to obtain funds to establish a leprosarium. However, the information I was able to salvage promises a more detailed analysis of caste composition in industry than any yet published.[29] There has as yet been no opportunity to work the material over carefully, but the crude tabulations that have been done on these 1951 data suggest no evidence of sub-caste clustering either in the plant itself or in any of the individual departments from which records are available.

Apart from the absence of evidence suggesting grouping by caste either in the plant or in individual departments, there are certain other conclusions that can be suggested. There were a surprising number of high-caste members working at every occupation, including the least skilled. Of 550 workers in "least skilled" categories in one fairly typical production department, 21 per cent were from various "twice-born" castes. This is exactly at odds with what is typically assumed, but it is supported by Lambert's evidence from Poona.[30] Nor is there any evidence from the dates of employment that suggests, as has been argued by some scholars, that the high-caste workers came into the workforce at a later date. All castes seem to have come to Jamshedpur at all stages. An equally striking point is that the departmental information suggests that an infinitesimally small proportion of the Tata Company's production workforce came from untouchable groups.[31] One finds "Brahmans" in larger numbers in the higher supervisory classifications. The concentration of high-caste people in these jobs is clearly associated with educational advantage and does not seem to represent any

[26] Shiva Rao, B., *The industrial worker in India*, 81–82, London, George Allen and Unwin, 1939.

[27] In fact, we cannot even be certain of this fact. The lumping together of all migrants from the United Provinces (now Uttar Pradesh) under the "caste" designation Bhayya ignores the possibility that many of these people who are employed in the weaving sheds may, in fact, be members of untouchable castes. *Cf.* the hint of this in Shah, M. M., Labor recruitment and turnover in the textile industry of Bombay Presidency, 177, unpublished Ph.D. dissertation, University of Bombay, n.d.

[28] Lambert, *op. cit.*, 31–42. To the extent that my questions require carefully distinguished sub-castes, Lambert's material is unsatisfactory because he lumps all Brahmans together regardless of sub-caste and he does not identify the castes of that 8.2 per cent of his sample that migrated from outside Maharashtra. It must be noted, however, that in the cited essay Lambert was concerned with somewhat different problems and his classification is sufficient unto his own needs. Dr. Lambert informs me that subsequent essays based on his Poona research will deal with many of the problems raised in this paper.

[29] The character of the information on these wage sheets is worth noting if only to permit us properly to bemoan the serious loss to scholarship implied by their destruction. On the wage sheets for each department in the Company's Jamshedpur operation appeared the name of every employee in the department, his date of birth, state and district of birth, date of employment, specific occupational classification, rate of pay, religion and (if Hindu) sub-caste affiliation. This is not meant as a reflection on the Tata Iron and Steel Company which is, after all, primarily concerned with the production of steel rather than with the storing of records for the convenience of scholars.

[30] Lambert, *op. cit.*, 31–42.

[31] Of a total of 768 workers employed in Steel Melting Shop III, only sixteen were from scheduled castes. (Another eighty-one, however, were from various tribal groups.) These figures may be deceptive as regards total employment of untouchable caste members by the Company. The departmental sheets available did not include the unskilled, undepartmentalized coolie labor which constituted about 20 per cent of the total production workforce. It is possible that untouchables would be found mainly employed as unskilled coolies. Unfortunately, these data were not available.

specific agglomerative tendencies of sub-caste elements. An analysis of district of origin suggests that there is no true sub-caste clustering.[32]

Reviewing the data available, we can only say that we really don't know whether or not there is any significant degree of grouping by caste in factory employment. The Jamshedpur data suggest that there is none, and they also suggest that there is little tendency for high-caste groups to avoid low-skill jobs. The Bombay data indicate only that untouchable caste groups do not appear in the weaving sheds of the city's textile mills. We have no way of knowing whether or not, apart from this, there is any tendency for non-Harijan caste clustering to occur in this department. Very generally speaking, however, the available evidence suggests that Hindus of all castes will seek and accept all jobs in the industrial sector and that this has been true historically. As early as 1864 the Census Commission of Bombay could write:

> It is supposed that at one time caste determined the occupation that a Hindoo was to follow. Now it is but a limited influence, and there are few castes of which the members will not engage in any occupation, and but few occupations in which persons of any caste will not seek a livelihood.[33]

Despite such a judgment, when looking at the problem from the point of view of labor force behavior, there are still two questions to be asked. First, which castes will accept the so-called ritually degrading jobs in factories? The typical answer one receives is that only untouchable caste members will take such jobs under any circumstances. However, it is important to note that there is no firm statistical evidence whatsoever to confirm or deny this proposition. Apart from this, there are a number of problems involved. To the extent that in factories the water closet replaces the honey bucket as the technology of human sewage disposal, it is possible that the issue of ritual pollution would be irrelevant.[34] Even if we were to accept the proposition that certain tasks are taken only by untouchable groups, we do not know whether these tasks will be taken by all untouchable castes or only by some. Finally, we have to be certain that any concentration of untouchable castes doing specific tasks is truly a function of selection by workers and not in fact the result of selection of these castes for these jobs by the employers.

The second question to be answered is whether or not there are certain jobs in which non-untouchable workers will not permit the employment of untouchable caste workers. The evidence from Jamshedpur suggests that there are no such jobs. On the other hand, the weaving sheds of Bombay's cotton mills are said to represent such a case. But we really don't know what this means until we have detailed studies in the Bombay weaving departments and comparative studies in other Indian textile centers. Even if the phenomenon is correctly described, it stands as an exception to the evidence from other departments in the cotton mill industry and other industrial situations. We will have to answer the question: why here and nowhere else?[35]

Moreover, if we discover that this phenomenon in effect pits all touchable castes against all untouchable castes,[36] we then have to ask whether or not this is a caste phenomenon or a device merely to preserve a monopoly of particularly advantageous but very limited economic opportunities against newcomers? In other words here, too, we know nothing about the nature of caste dynamics.[37]

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[32] On the wage sheets Brahmans were classified as such without indication of specific sub-caste. However, an analysis of districts of origin indicated that Brahmans came from all over the country. This geographical scatter makes it safe to suggest no sub-caste clustering.

[33] *Census of the island of Bombay, taken 2nd February 1864*, xviii, Bombay, 1864. A similar comment can also be found in the *Census of the city and island of Bombay taken on the 17th of February 1881*, 42, Bombay, 1883.

[34] E. M. Forster, in a preface to Anand, Mulk Raj, *Untouchable*, 6, Bombay, Jaico Publishing House, 1956, has written: "No god is needed to rescue the Untouchables, no vows of self-sacrifice and abnegation on the part of more fortunate Indians, but simply and solely—the flush system. Introduce water-closets and main-drainage throughout India, and all this wicked rubbish about untouchability will disappear." The issue is, of course, much more complex than this. For example, there is the evidence of concentration of certain untouchable groups in specific occupations in the leather goods industry of Kanpur, a phenomenon associated with the ritual uncleanliness of the material involved. However, once again there are no adequate studies.

[35] In fact, in 1892 a Factory Inspector commented that the "refusal of men of one caste to work with those of the other has been singularly rare in the textile trade." Royal Commission on Labour, *Foreign Reports* **2**: 136, London, Her Majesty's Stationery Office, 1893.

[36] It is not quite accurate to refer to "touchable" castes. However, in this context the meaning is clear and any effort to be more precise terminologically would be awkward.

[37] In south India, particularly, the conflict seems to pit not only touchables against untouchables but also, in a most complex fashion at the same time, non-Brahmans against Brahmans. *Cf.* Parthasarathy, *op. cit.*

IV

It must be recognized that not only those who seek employment but also those who employ are both intimately involved in the caste system and are largely affected by the traditions and institutions from which they as human beings derive. The employer, as a caste-affected person, may seek to give employment to his caste brethren. This may make for a tendency for certain castes to find employment in certain companies of an industry, even if not in the industry itself. However, none of the data from Bombay, Poona, or Jamshedpur suggest such a situation.

But even if the employer does not recruit the bulk of his labor force from the members of his own sub-caste group, he may still have views and prejudices as to the appropriate distribution of jobs among available castes in terms of caste-skills, appropriate mixing, and the like. There are scattered data suggesting this possibility.[38] However, we don't really know the extent to which such judgments affect the occupational pattern. What data there are from Jamshedpur suggest that special selection seems to have to do with regional rather than caste characteristics, a function in part of the special physical requirements for some jobs.[39]

On the whole, the statistical data we have suggest no significant caste clustering, and thus no evidence of any significant selective policy on the part of the employer where firms are large. On the other hand, it has been argued that where the actual power to hire is given into the hands of foremen, as was true in the Bombay mills, the individual foreman used this authority to build his power *vis-à-vis* the employer and to augment his income. While the power objective might be strengthened by the selection of caste brethren with some endogamous basis for loyalty, such a consequence does not follow in a market characterized by substantial underemployment. The income possibilities (i.e., the opportunities to collect fees from workers anxious to get and hold jobs) might well be enlarged by ignoring caste ties altogether and giving employment to whosoever has the ability to pay the greatest bribes. Nor would this necessarily weaken jobber power against the employer. Unfortunately, here as elsewhere the evidence is cloudy. We do not know whether the foreman, when he has the employing power, selects on the basis of caste affiliation or village, religious, and linguistic links, or on the basis of a purely money nexus. It may, of course, even be possible that skill for the job is a relevant consideration.[40]

On the whole, one would suspect that caste association would be most important in the smallest factory centers where the labor force is drawn from the immediate neighborhood. It would probably be less important in larger centers such as Bombay, where the labor force is drawn from wider regions, and it is likely that it would be of least significance in places such as Jamshedpur which draw on a thoroughly cosmopolitan labor pool. But we really do not know anything about the way employers hire people, and we have no comparative studies whatsoever.

And just as we know virtually nothing about the process of employment, similarly we know very little about the process of upward mobility inside the factory and the degree to which it is caste-linked. Will there be concentrations of castes within departments by level of skill? There are some suggestions that in the spinning departments of the Bombay mills, although untouchable groups are a significant proportion of the labor force there, they tend to be restricted to the least-skilled classifications of those departments.[41] Yet there is other evidence that suggests that all castes can be found at virtually all levels of authority. The Jamshedpur data, while not completely clear, indicate this. To what extent is it educational

[38] Mehta, *op. cit.*, 121. *Cf.* also *Report, Indian Factory Labour Commission* **2**: 82, Simla, Government of India Central Press Branch, 1908; and Burnett-Hurst, A. R., *Labour and housing in Bombay*, 49, London, P. S. King, 1925.

[39] Whatever complaints have occurred in Jamshedpur regarding special selection of workers have arisen over purported discrimination in favor of special regional groups. Caste has never been a factor on these occasions, if the records are to be believed.

[40] The literature is very vague but some scholars have suggested that caste was a decisive factor in hiring. *Cf.*, Shah, *op. cit.*, 176. *Cf.* also RCL, *Evidence* **1** (1): statement of M. S. Bhumgara, 502; RCL, *Evidence* **1** (2): testimony of representatives of the Bombay European Textile Association, 332 and 337, questions 5448 and 5581–5582; Buchanan, *op. cit.*, 416. Generally, however, the evidence is that it was the income possibilities to be obtained from bribes and not caste that determined the hiring of workers. For an examination of much of the literature on this subject, *cf.* Morris, Morris David, A history of the creation of a disciplined labor force in the cotton textile industry of Bombay City, 1851–1951, 292–372, unpublished Ph.D. dissertation, University of California, 1954.

[41] Shah, *op. cit.*, 179. If this is true, it makes the Bombay Millowners' 1940 survey less useful than I have already suggested.

advantage rather than caste-status that makes the difference? We don't know.[42]

An interesting aspect of factory caste relationships is raised by the provision of certain welfare facilities for workers—canteens, creches, and housing. There is no substantial evidence to indicate that there have been any serious problems raised by arrangements that in the villages represent quite sensitive areas of intercaste relations. However, it is impossible to determine whether the absence of information indicates the silence of efficient accommodation to caste prejudice or the complete irrelevance of caste.[43]

V

Finally there is the critical issue of cooperation among workers in defense of their interests against employers, the problem of strikes and unions. Despite the attention scholars have so assiduously lavished upon the Indian working class, they have with equal steadfastness ignored the relationships between caste and strikes. What evidence there is seems to indicate that caste has been virtually irrelevant in the strikes that have afflicted Indian factories in the past eight or nine decades. On the other hand, at least three scholars have suggested that employers have pitted some castes in the role of strikebreakers against other caste groups. It has been suggested that this has been the device by which various new castes have occasionally broken into the Bombay cotton textile industry. However, it is not clear that these incidents referred to typically involved caste; many of the references are, in fact, to the pitting of different regional groups against one another.[44] Generally, the occasions when employers have so used the caste device seem to have been remarkably few when one considers the sharp intercaste conflicts that can occur in the village situation.[45]

The literature on trade unions is equally silent, bewilderingly so. All we have are a few crude generalizations. For example, V. V. Giri, a long-time trade unionist, has commented on the weakness of Indian unions as contrasted with those in the West:

> But in India there is caste consciousness, which represents the occupational classification of the society. Communalism and casteism have been the worst enemies of trade unionism.[46]

Yet one finds the vast majority of writers tending to the conclusion that Indian unions are notably free of caste influences. For example, a frequently cited authority tells us that "One of the most happy features of Indian trade unionism is that it is comparatively free from communal and religious warfare."[47] Unfortunately, the statements on both sides of the issue are equally unsupported by any evidence whatsoever. The fact that Indian unions are typically industrial in structure suggests that caste is of little significance. On the other hand, until we have some analysis of union membership and leadership in caste terms we shall be unable to make any intelligent comments.

VI

In summary, what can we say about caste, omnipotent and ubiquitous in the countryside, as it functions in the industrial environment? My conclusion is that we know virtually nothing about the behavior of those social units that are so significant in the villages. Moreover, where scholars have favored us with gratuitous and undocumented *obiter dicta*, they have almost invariably confused caste, village, religious, linguistic, and regional categories.

Viewed in the context of economic change and development, however, the evidence from Jamshedpur and even Bombay does barely hint at the possibility that caste as it is considered at the village level is virtually irrelevant to the recruitment, utilization, and behavior of the labor force in industry. While caste certainly persists in the urban setting, it seems to be unimportant in industry and to the process of industrialization.

If caste relationships of the village type are irrelevant to the process of industrialization, it is possible that a new kind of functioning unit will emerge that is composed of members from many castes. There are hints that industrial problems may be associated with the larger relationships

[42] Of course, even if educational advantage is the factor that determines upward mobility, it is possible that educational advantages have been the result of pre-existing caste monopolies in the villages and towns. But this is a different problem altogether.

[43] Burnett-Hurst, *op. cit.*, 115.

[44] Mukerjee, R., *op. cit.*, 356; Shah, *op. cit.*, 179; Mehta, *op. cit.*, 121.

[45] Punekar, S. D., *Trade unionism in India*, 152ff., Bombay, New Book Co., 1948, does not list caste as one of the many devices which employers use to divide workers one from another. *Cf.*, also, Desai, A. R., *Social background of Indian nationalism*, 229 and 247, London, Oxford University Press, 1948.

[46] Giri, V. V., *Labour problems in Indian industry*, 52, Bombay, Asia Publishing House, 1958. *Cf.*, also, Murphy, Gardner, *In the minds of men*, 75–76, New York, Basic Books, 1953.

[47] Punekar, *op. cit.*, 129.

of touchable *versus* untouchable and Brahman. These, in the context of economic growth and change, may be associated with access to education and the persistence of pre-existing monopolies of economic opportunity. In such an event, however, it is not caste as it must properly be described that is at stake, but something rather more like class that is really operating. And here the issues will not be substantially different from those faced in the economic history of North Atlantic industrialization.

One concluding remark must be made. In my analysis I have unfortunately not had space to consider the relevance of caste to entrepreneurship. Here, the role of caste seems to have been grossly overstated. Looked at in detail, I feel certain that the historical record will show that the financing and management of Indian industry during the past century has not been caste-oriented as much as it has been a function of extended-family relationships. It has been a phenomenon not unlike that characterized by the Welsers and Fuggers of late medieval times or the family firms of the early industrial revolution, a function of the small size of enterprise in the early stage of India's industrial transformation.

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THE CULTURE OF KABIRA, SOUTHERN RYŪKYŪ ISLANDS[1]

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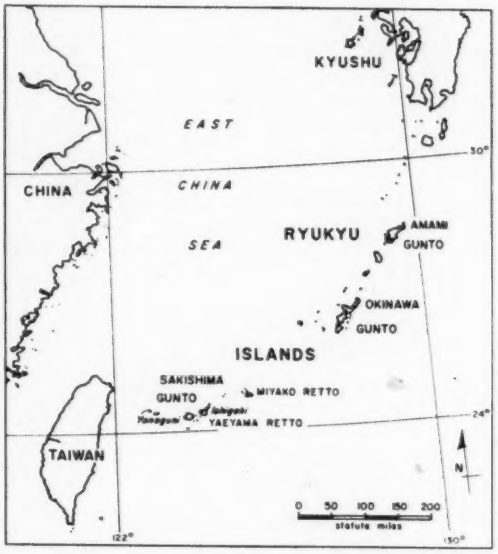
THE SETTING

PHYSICAL ENVIRONMENT

THE Ryūkyū archipelago is customarily divided into three island clusters or *guntō*[2] (map 1). At the southwesternmost end of the southern cluster (Sakishima Guntō) is a group of ten populated islands which together comprise Yaeyama Rettō (maps 1 and 2). Of these ten islands, Ishigaki Island is among the most important: with its 27,075 inhabitants (1950 census)[3] it is by far the most populous member of the *rettō*, and with an area of approximately 100 square miles[4] it stands as second only to Iriomote in size. Isolated on the northwestern corner of Ishigaki Island is the community of Kabira, the contemporary culture of which is here described.[5]



MAP 1. The Ryūkyū Islands in relation to Taiwan, China, and Japan. The Yaeyama Rettō division of Sakishima Guntō, Yonaguni Island excepted, appears in greater detail in map 2.

The community consists of a central village area and of a subsistence area encircling the village (map 3). The village is formed of individual dwelling units, or compounds, neatly

[1] This report summarizes data secured by my wife (Trude Smith) and me during eight months of joint field work in Kabira in 1950 and four months in 1952. The initial research was made possible by grants from the Social Science Research Council and the Wenner-Gren Foundation for Anthropological Research, Inc., and was facilitated by assistance from the Washington State University and the Department of the Army. The continuing research of 1952 was carried out as one project of the 1951–1952 Scientific Investigations in the Ryūkyū Islands (SIRI) program, which was financed by Department of the Army funds and was organized and directed by the Pacific Science Board of the National Research Council. We wish to record here our indebtedness to these several organizations. We desire also to express our gratitude for the substantial aid and many kindnesses extended us in the Ryukyus by the personnel of the United States Civil Administration of the Ryukyu Islands, in particular by members of its Civil Information and Education Department, Programs and Statistics Section, and Yaeyama Civil Administration Team.

Since this report is devoted to culture description, comments and comparative notes are out of place. A great many matters, however, deserve comment: e.g., the Kabiran evaluation of the typical Miyakoan personality and Weltansicht (p. 139), the possibility of a Shiva influence in the cylindrical stones of the garden shrines (p. 146), the Korean-like aspect of the former assignment of government posts to nobility (p. 157), and the Kabiran criteria for distinguishing sex in plants and shellfish (p. 150).

[2] To distinguish Kabiran dialect from Japanese words, the former are designated by the symbol "(K)" at their first occurrence. As in this instance, virtually all toponyms and geographical terms are given in their Japanese forms.

[3] United States Civil Administration of the Ryukyu Islands, Programs and Statistics Section, *Ryukyu Islands economic statistics*, Bulletin No. 17: 1, March, April, and May, 1952.

[4] *Ibid.*

[5] As observed in footnote 1, the period of description is that of 1950–1952. The present tense is employed throughout in referring to the general cultural practices of this period. This use of the historical present makes it possible to reserve the past tense for an occasional comment upon the situation prevailing at earlier time levels, thus distinguishing clearly information based upon our own observations from that resting upon other sources. Inasmuch as the village has not been visited by the author since 1952, the extent to which the pattern of Kabiran life has experienced change subsequent to that year is not known.

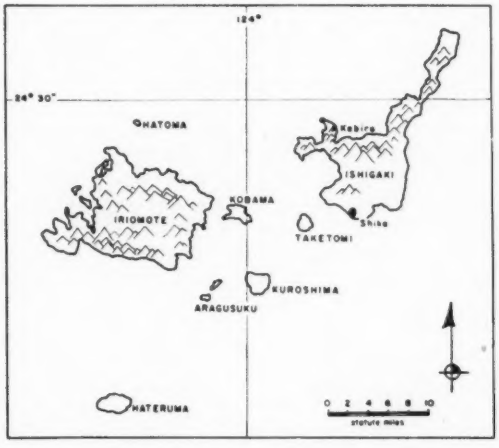
and compactly arranged upon an uplifted marine terrace which inclines gently southeastward. The surrounding subsistence area includes the peripheral portion of this terrace but extends beyond it in every direction. It is comprised, in general, of two concentric zones, an inner one of intensively cultivated fields and an outer one, less important economically, of steep forested mountains on the east and south and of shallow sea-arms on the north, east, and west.

The significant features of the subsistence area are arranged about the village proper in the following manner (map 3).

(1) Immediately to the east and southeast of the village are a few dry fields. Beyond these lies Kabira Bay, with a string of protecting islets across its mouth (fig. 1). From the east shore of this bay a range of densely forested peaks rises quite steeply; ascending to an elevation of 1,700 feet, this range forms the backbone of the island. The crest of these mountains marks the limits of the Kabiran subsistence area in this direction.

(2) Along the southern and southwestern limits of the village extend two strips of tilled fields, first a narrow line of dry fields and then, down the floor of a very small stream valley, a single series of paddy fields. The southern rim of this stream valley climbs abruptly, its slopes interlocking with neighboring slopes to form an intricate knot of mountains. Luxuriantly timbered and attaining a height of nearly 1,000 feet, this mountain mass extends from Kabira Bay on the east to the sea on the west. Much of this area is exploited by the Kabirans as a source of wood and forest products.

MAP 3. The village of Kabira and its surrounding subsistence area. Pisidaama, a tiny community of recent Miyakoan immigrants, appears at the foot of Kabira Bay. Nakamamuri, the ancient site of Kabira, is on the knoll to the west of the present village. Note the mountains and upland area which separate the Kabiran community from the rest of the island to the south. The symbols carry the following significance: mattock: dry fields; concentric arcs: paddy terraces; *gaara* fish: fishing areas; conch: shellfish gathering grounds; horse: community grazing range; grass spears: areas of tall grass; tree: forest districts. Dashed lines indicate the dirt road to Shika (see map 2) and the two main paths to the principal agricultural areas.



MAP 2. Yaeyama Rettō (sometimes termed Yaeyama Guntō), showing nine of the ten populated islands. Yonaguni, lying well off to the west and hence missing here, is shown in map 1. Aragusuku is a group of two islands. The locations of Kabira village and Shika (Ishigaki City) are indicated.

(3) To the west and northwest of the village, the terrain is relatively level. On the western portion of that terrace upon which the village stands and on the lower surface still farther west, which forms the base of the peninsula that juts northwestward into the East China Sea, are the principal wet and dry field areas of the community. Close to the tip of the peninsula, where the surface rises to high hills and is grown to grass and clumps of bushes, is the communal animal range. Fringing the fields on the west—but not to the northwest where the tip of the peninsula

FIG. 1. Mouth of Kabira Bay, looking northeastward from Kabira over the islands that all but block the entrance. Beyond lies the reef and an expanse of open water. In the distance rises the mountain chain that forms the long northeastern peninsula of Ishigaki Island.

breaks the low coast line—and separating them from the shore is a narrow line of dense pandanus and other beach vegetation, which serves as a source of plant materials and an important typhoon defense. The shore itself, on both the west and the northwest, is composed of curving white sand beaches alternating with rough raised-coral headlands. Between the shore and the nearby reef stretches a shallow lagoon of clear green water, an important source of sea food. Finally, several hundred yards offshore, and paralleling the shore line throughout its length the narrow coral reef rises to the surface of the sea. Beyond the reef lies the blue open sea, which, even in calm weather, throws long white combers endlessly against the coral mass. But unlike the reef, the sea falls outside the Kabiran area of exploitation.

(4) On the north and northeast a strip of dry fields, sandy and unproductive, flanks the village (fig. 5). Then come in order, as on the west, the strip of beach vegetation, the shore of sandy arcs and abrupt headlands, the lagoon, and the living reef. And again beyond the reef lies the deep sea, here an unbroken expanse to the horizon.

The mountains east of Kabira Bay, those beyond the paddy and dry fields to the south of the village, and the sea at the other two compass points have isolated Kabira effectively, though not completely, both from the remainder of Ishigaki Island and from the rest of Sakishima Guntō. This isolation has permitted the development in Kabira of a distinctive dialect, a series of apparently unique culture traits, notably in the realm of religion, a marked ethnocentrism, and a traditional pattern of village endogamy.

Because Ishigaki Island lies only sixty miles north of the Tropic of Cancer and its shores are bathed by the warm waters of the Black Current, Kabira experiences a subtropical, maritime climate with moderately high temperatures and excessive humidity year-round. The rainfall is heavy, particularly in summer, reaching an annual average of about 87 inches; actual participation is, however, highly irregular both by month and by year. Two or three times during the warmest season of an ordinary year the rains attain deluge proportions and the winds reach typhoon velocity. The normal winds, however, are monsoonal in character, from the north in winter and from the south in summer.[6] The soil varies from an extremely sandy composition, as in the zone between the village and the northern shore and likewise on the northwestern peninsula, through a sandy loam on the mountain hillsides to a rich, black mud in the paddy fields. The soil, altitude, and position with reference to the sea differ sufficiently in the various sections of the community to support, under the prevailing mild and humid climate, a rich and varied native flora, including forms as diverse as pines and tamarisks on the one hand and, on the other, pandanus, palms, cycads, papaya, bamboos, and numerous other subtropical varieties. Indigenous fauna is limited in its mammalian forms to rats, insectivores, bats, and wild pigs. It includes, however, many reptiles, notably the several types of highly venomous pit vipers that abound in the mountains, fields, and even the village. Large land and water birds, including ducks and other migratory fowl, are occasionally to be seen. Octopus, eels, squid, shrimp, sea snakes, and small fish in uncounted varieties normally teem in the bay, lagoon, and reef, and edible shellfish of many types are common along the shore.

POPULATION

In 1950 the total population of Kabira was 724 persons. This figure includes recent immigrants to the village from Miyako Rettō seventy-five

[6] These precipitation and wind data are from the meteorological records of the Japanese weather station in Yaeyama, as summarized in Navy Department, Office of the Chief of Naval Operations, *Civil affairs handbook, Ryukyu (Loochoo) Islands*, 5-11, Washington, 1944.

miles to the east-northeast (map 1) and from the town of Itoman on Okinawa, but excludes the inhabitants of the separate hamlet of *Pisidaama* (K)[7] (map 3). Of this total, 676 individuals resided in households which may be considered to be truly Kabiran, i.e., households in which the head or his spouse was a native Kabiran. Numbered among these 676 persons are non-Kabiran spouses of true Kabirans and coresident parents and siblings of these spouses, children of Kabiran ancestry who chanced to be born outside the community, maids of non-Kabiran birth, and the like. Of these 676 persons, 331 (49 per cent) were male and 345 (51 per cent) female. This group was apportioned among 140 household units, the average household embracing 4.8 persons. According to the official records maintained in Shika (often called Ishigaki City), the trade and government center on the southwestern tip of the island (map 2), the crude birth rate in Kabira averages about 34 per 1,000 but the Kabira midwife's figures reveal that not all births are registered. Evidently the government records underestimate the correct birth rate by at least 10 per 1,000.

In their racial affinities the Kabirans are basically Mongoloid, of the peripheral or "unspecialized" type.[8] None the less, they deviate sufficiently from the typical Mongoloid in enough morphological traits to suggest the presence of one or more appreciably divergent strains. Notable in this connection are the high frequency of facial freckles among females and the common occurrence of wavy, dark-brown hair, of a straight and even convex nasal profile, and of moderately heavy facial and body hair among males. Moreover, the external eye fold occurs much more commonly than the complete and inner canthic types, which are, in fact, individually no more frequent than the median variety. Finally, about 35 per cent of the true Kabira population possesses blood of group B, the highest frequency of this type yet reported for the Ryūkyū archipelago.

HISTORY

The history of Kabira is little known. No systematic archaeological research has yet been undertaken in the community area or, for that matter, in Yaeyama. Local traditions seem to be surprisingly few. Most either relate visions experienced by ancestral Kabirans, at the instance of supernatural forces, or recount in truncated form the exploits and achievements of locally famous persons of Kabiran birth. Though some evidently report actual events which occurred as much as three centuries ago, these provide merely historical fragments. The native language being unwritten and a mastery of spoken and written Japanese being essentially an attainment of this century, no written documents of historical importance have been recorded within the community. Finally, if the published material on Yaeyama history affords proper basis for judgment, the meager historical records of the more culturally progressive centers of the *guntō* rarely mention Kabira and hence are of little aid in reconstructing the village past.

According to local tradition, the village was once a tiny hamlet situated on the slopes of the prominent hill now called *Nakamamurī* (K) (fig. 2), about a quarter of a mile west of its present location (map 3). The time of its actual founding on this hillside is entirely obscured in the haze of antiquity, but tradition, chronicling events which knit with known facts of Yaeyama and Ryukyuan history, demonstrates its existence there by A.D. 1500. The continuing fortuitous discovery of numerous artifacts by villagers as they till the slopes of this hill confirms a former occupancy of this site. These artifacts include "curved jewels" (*magatama*), stone celts and adzes,

FIG. 2. Hill known as Nakamamurī to the northwest of Kabira village. On the slopes of this eminence, according to tradition, the village once stood. This tradition is supported by artifacts uncovered by contemporary Kabirans during their agricultural pursuits.

[7] For the meaning of this symbol, see footnote 2 above.
[8] See Wm. Howells, *Mankind so far*, 250-251, Garden City, Doubleday, Doran, 1944.

hammerstones, pottery elbow-pipes, and great quantities of pottery fragments, which are partly thick, crude ware of Yaeyama manufacture and partly finer, glazed trade types. One stone pipe bowl, perforated to receive a stem, has been uncovered at this locality; this find suggests the persistence of effective stone-working techniques until after the introduction of tobacco, which could not have occurred before the late sixteenth century. When the village moved to its present location is not clear, but the move unquestionably antedated the past hundred years and is remembered as one which was gradual rather than abrupt.

Whatever the location of the village, Kabira traditions, supported by the established facts of Yaeyama history, testify that it was to some extent under the political control of the Okinawan kingdom from the fifteenth century to the close of the nineteenth. During this period the two highest village officials, both non-Kabirans and members of the nobility, were direct appointees of the Yaeyama representative of the Okinawan king. But the principal contact of the villagers with the monarchy was through their observance of the government requirement that they serve as unpaid cultivators of the extensive government-owned paddy areas in the neighborhood of the village, by the crops of which the bureaucracy was supported, and that they pay oppressive head-taxes in rice and home-woven cloth.

Shortly before the end of the last century the Okinawan kingdom was absorbed into the expanding Japanese empire. Kabira first felt the effects of this new political alignment about fifty years ago when certain cultural changes were ordered throughout the southern Ryukyus by the new government. Notable among these were the abolition of the native aristocracy, the institution of an elementary school system with compulsory attendance, and the proscription of various local customs, such as hand tattooing, which the Japanese found offensive. Other modifications in the fabric of Kabiran culture occurred more gradually, many as a result of voluntary change on the part of the Kabirans themselves. Perhaps the most important of these was the substitution of new plant strains of higher yield or otherwise superior characteristics, developed by the Japanese experimental agricultural program, for traditional plant types. But despite these cultural innovations, the basic pattern of Kabira life continued without serious modification.

By the time of World War II, Yaeyama was sufficiently assimilated within the framework of the empire to participate actively in its military campaigns. Although a few Kabiran young men were inducted into the Japanese armed forces and were sent overseas, most were impressed into the labor battalions which served the military throughout the *rettō*. Kabira saw little of the actual hostilities, no more than a few brief air raids. Nevertheless, its residents felt indirectly the impact of war: for example, they were ordered by the commanders of the small Japanese military posts near the village to abandon their homes and fields, and hence were forced to live for months in privation in the mountain forests.

Postwar American contact and influence have been minimal. In 1952 only three conspicuous contributions of America to Kabira were recognized: the building of the first road passable to vehicles between Kabira and other towns of the island, the construction of a new school building, and the establishment of an effective antimalaria program through free distribution of atabrine. It was known, of course, though the motive was not comprehended, that American regulations forbade the once profitable trade between Yaeyama and Formosa. But the effect of this order upon Kabira, like most other activities and directives of the Americans, was neither direct nor serious.

Of far more consequence to Kabira than any direct American influence has been the postwar influx into the community of immigrants from the Okinawan district of Itoman and, more especially, from the island of Miyako. In 1950, households which had immigrated from one or the other of these localities and established themselves within the village numbered 48 persons (34 males, 14 females), making up the difference between the 676 figure presented above as the total membership of the Kabiran households and the 724 total population of the village. In addition, another 66 Miyakoans (32 males, 34 females) lived in that year in the nearby settlement of *Pišidaama*, which was, in point of fact, an exclusively Miyakoan hamlet.

The Itoman folk, semi-migratory fishermen, maintain themselves by taking fish from the waters of the lagoon and the sea beyond, and by peddling their catch among the village inhabitants. To the keen annoyance of the Kabirans, they customarily employ explosives, a practice so outrageously wasteful that the lagoon, formerly continuously productive under the Kabiran's

primitive fishing techniques, was in 1952 all but stripped of its marine population. In contrast, the Miyakoans have established poor but permanent residences on the fringe of the village and in *Pišidaama*. They live a meager, marginal existence. As farmers, they till community-owned dry fields; as professional firewood-gatherers, they cut indiscriminately in the neighboring forests, bundle the wood, and send it south to Shika for sale; and as salt-driers, they evaporate coarse, gray salt from brackish in-shore water over primitive hearths, stoked with valuable firewood, and sell the product in the city. Their primary effect upon Kabira is that of stripping the nearby forests of firewood and timber. This compels the native villagers to search in more distant mountains for their wood. While the fishing methods which find favor among the Itoman people are deplored and certain of their personal habit patterns are thought strange and incomprehensible, the people themselves are generally respected as honest and industrious. To the contrary, the Miyako immigrants, whose pattern of life approximates on a lower plane that of the Kabirans themselves, are universally depreciated as shiftless rascals, almost destitute but too deficient in initiative to deserve more than they now possess.

LANGUAGE

Two languages are current in Kabira, Japanese and the native dialect. With the exception of the villagers beyond the fifth decade of their life, who often know only the latter, all Kabirans are bilingual. The two tongues are employed on different levels of communication. Japanese is the language of school instruction and of all written communication; it is likewise employed when villagers meet people, from portions of Yaeyama and still farther afield, whose local tongue is sufficiently different from Kabiran to render conversation in the native idiom difficult. In contrast, Kabiran is the speech of the normal home and village situation: customarily only the dialect is heard within the community day after day as the natives proceed with their usual tasks.

Kabiran is a distinctive linguistic form peculiar to this village, though belonging to the Ryukyuan subunit of the Japanese-Ryukyuan linguistic stock. It is mutually intelligible with several dialects of adjacent portions of Ishigaki Island, including that of Shika, and of some of the neighboring islands of the Yaeyama group, e.g., Taketomi, Kobama, and Iriomote. Though not widely divergent, it is reported by informed Kabirans to be unintelligible to certain other speech communities in the Yaeyama area, including those of the islands of Hateruma, Kuroshima, Aragusuku, and Yonaguni (maps 1 and 2). Preliminary examination of comparative vocabulary lists suggests the probability of a closer kinship of Kabiran with Miyakoan than with some dialects of its own island cluster. Consonant with their still more distant geographical position, Okinawan and Amamian bear considerably less similarity to the village dialect than does Miyakoan.

The phonemic structure of Kabiran greatly resembles that of standard Japanese, approximating it more closely than do many Ryukyuan speech forms. However, as is common in the southern islands of the archipelago, Kabiran possesses a sixth vowel phoneme, a high, central, unrounded variety (*ï*) which is generally the equivalent of the Japanese *i* but sometimes of *u*. Also unlike Japanese, Kabiran permits spirants and nasals in geminate clusters in word initial position. A special characteristic of the dialect is the exceptional frequency of unvoiced vowels, apparently often, if not invariably, positionally conditioned, nonphonemic variants of their voiced correspondents. As in Japanese, vowel length and syllable pitch are phonemic entities, although they operate on distinctly different levels of importance. Even though many Kabiran morphemes are obviously cognate with modern or at least archaic Japanese forms, a residue without immediately apparent relationship to Japanese remains. The analysis of this vocabulary segment from the point of view of possible linkages external to the Japanese-Ryukyuan linguistic stock should prove enlightening. Grammatically, Kabiran exhibits complexities unknown in contemporary standard Japanese; for example, the Japanese object postposition *o* has no dialect equivalent, word order alone answering this relational function, and, under certain conditions, the role of the Japanese subject-of-discourse postposition *wa* is assumed by declensional modification of the terminal vowel of the substantive.

SUBSISTENCE

The economic structure of Kabira is based upon intensive agriculture, supplemented to some extent by the use of domestic animals, by casual fishing, and by incidental gathering of shellfish and wild plant products.

AGRICULTURE

All crops, except some rice, are raised in the subsistence area in the immediate vicinity of the village (map 3). The implements employed in tillage are normally carried to the fields each day as they are needed. Chief among these are a primitive steel-tipped plow of the lister type or a recently introduced and always imported single-moldboard plow (fig. 3), a sickle with a straight metal blade set at right angles to a short wooden handle, a short-handled mattock, and a weeder. Fertilization with night soil, animal manure, and vegetable refuse, together with careful crop rotation, guarantees a maximum yield when rainfall is adequate and typhoons are not destructive. As with virtually every activity in Kabiran life save house construction and ceremony preparation, agricultural tasks are generally performed by individuals singly. Group activity occurs only in rice transplanting and harvesting, soybean threshing, and the like, and even in these instances the cooperating unit rarely exceeds a half dozen individuals, characteristically all relatives.

Rice, both glutinous and nonglutinous types in several varieties, ranks first among the cultivated plants in prestige, and is made to bulk as large as possible in the family diet. The climate permits two crops annually, one ripening in May and the other in November. The plant is cultivated in strips of earthen-walled wet fields, constructed along the floor of stream valleys where the requisite water can be obtained by gravity flow from natural sources. No water pumps or complicated irrigation channels are employed in Kabira.

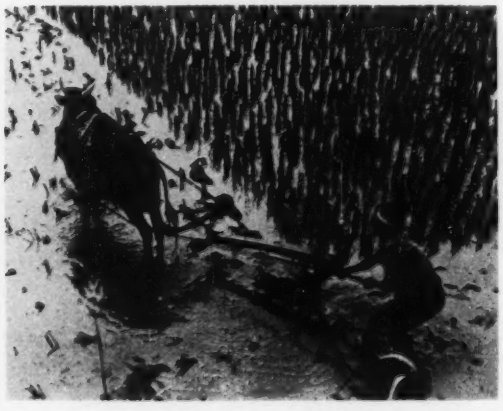


FIG. 3. Turning under the rice stubble with an imported, new style, single-moldboard plow.

FIG. 4. Man and young girl of Une Ishito household rippling millet in village street.

When the soil has been turned over by a man with a long-handled mattock or plowed with the aid of a bull or water buffalo (fig. 3), a special seedbed area is laid out within the field, ditched to insure proper drainage, and smoothed with a canoe paddle. After having been allowed to stand moist for two or three days to sprout, the seeds are sprinkled over the surface of the bed and are covered thinly with a float of mud, both tasks being performed exclusively by men. When about two weeks old the seedlings are pulled, bundled, and transplanted to the various growing-fields by adult family members of both sexes. In the course of the growth period two weedings are required. Harvesting, a tedious but joyful activity, is carried out with the sickle. As they are cut, the stalks are made up into small bundles with binding strands of straw. The bundles are next stripped of their grain near the field, an operation now generally performed with the aid of a simple Japanese-made threshing machine consisting of a cylinder, provided with projecting wire wickets, rotated by means of a treadle (fig. 4). The grain is then sacked and carried to the compound where, before being stored, it is thoroughly sun-dried on mats in the house yard. In addition to wet rice, some upland rice is also

raised, though its flavor is generally regarded as inferior.

From a strictly practical point of view, sweet potatoes are of far greater consequence than rice. They not only bulk larger than rice in the diet of every villager and much larger in that of most families but also supply the basic food of the horses and pigs. They are, moreover, of unique importance inasmuch as they survive most typhoons and adverse conditions which destroy other cultivated plants. Still another of their virtues is the simplicity of their cultivation: this involves hardly more than the planting of vine slips, by women, in elevated rows across fields which have been previously plowed by men. An additional valuable attribute is the rapidity with which the plants develop and the potatoes mature. Finally, the vines grow year-round and the tubers may be harvested at all seasons.

Other common crops that are raised in fields beyond the village limits, as are the rice and sweet potatoes, include wheat and millet (fig. 9), both winter-planted, and sesame (fig. 5); soybeans and small red beans; peanuts; and sugar cane. To supplement these important crops, many additional food plants are tilled within the village in small plots near the household compound. In such plots are planted several varieties of yams, taro, onion-like bulbs, large white radishes (*daikon*), squash, watermelons, tiny red peppers, greens, and, as recent introductions into Kabira, manioc and small tomatoes. Moreover, tiny vegetable plots are customarily set aside even within the compound itself. In these miniature gardens grow, with a minimum of attention, plants yielding foods which may be gathered in small quantities more or less continually to add welcome variety to the family's meals, in particular dry taro, squash, gourds, ginger, sugar cane, and red peppers. Occasionally a few square feet can also be spared beside the house for a patch of strong tobacco.

FIG. 5. Bundles of sesame leaning against a pole-rack before being brought in to the storeroom within the family compound. This field, sandy and dry, lies to the north of the village.

Cultivated fruits are limited to edible bananas, set out in groves near or beside the dwelling, and a few papaya planted within the compound.

Many of the plains and hillsides in the immediate vicinity of the village are now under intensive cultivation. Nevertheless, more arable land exists which might be cleared of its thick jungle growth and planted to dry crops, though the task of hewing out these fields is most laborious. It appears, in fact, that a substantial expansion of even the paddy field acreage might be possible were some means of artificially raising water to higher levels employed. Until the last few years, however, the possibility of extending the land under cultivation was of little practical moment, for no new fields were needed beyond those occasional plots required as substitutes for exhausted land. This situation prevailed because the resident population remained essentially stable, a high death rate cancelling out any natural, normal increase. Since 1947, however, population pressure upon the currently tilled land has at last begun to be felt. This has come about partly as the result of the arrival of the Miyako immigrants mentioned above and partly as an effect of the introduction of atabrine, which, reducing the hitherto withering death rate from malaria, has triggered a native population increase. Now that the community is losing its former isolation, younger sons are beginning to emigrate from the village, primarily to Shika as commented upon below. But emigration cannot be safely relied upon to siphon off the excess from the growing population. It is fortunate for the future stability of Kabiran society that the means of supporting an expanding village through enlarging the tillage area still exists within the community subsistence area.

FISHING

There are no native Kabirans who may properly be classed as fishermen, and, what is more, no Kabiran male would consider it a compliment to be so designated. Fishing is a casual occupa-

tion of most adult men of the village: once or twice weekly a man, alone or in the company of a friend or two, tries his luck in the lagoon or bay but he never ventures into the open water beyond the reef.

Several fishing methods are in favor. In a commonly employed technique, a spear (fig. 6) is driven into any fish, eel, octopus, or other edible sea creature which appears before the fisherman as he swims expertly about in the lagoon or probes among the holes in the reef. On occasion, small circular nets with cowrie weights bound to the periphery are thrown as the man

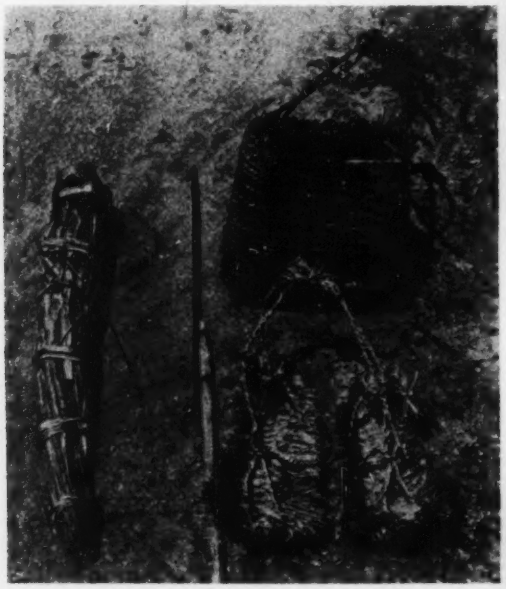


FIG. 6. Gear used in night fishing: metal-tipped spear, pine-splint torch, woven soft basket, and straw sandals to protect the feet from the rough coral.

wades close offshore; or long seines (fig. 7), dyed brown-red with pig blood, are drawn by two or more fishermen around fish in schools. Often round basket traps (fig. 8), fashioned of split bamboo and provided with a central opening and an internal funnel, are baited with steamed sweet potatoes, weighted with a stone, and sunk from a dugout to the bottom of the crystal-clear bay; there they remain until drawn to the surface with their catch of small fish with the aid of a hooked pole. Angling from dugouts with hook and line is another method sometimes followed. After the

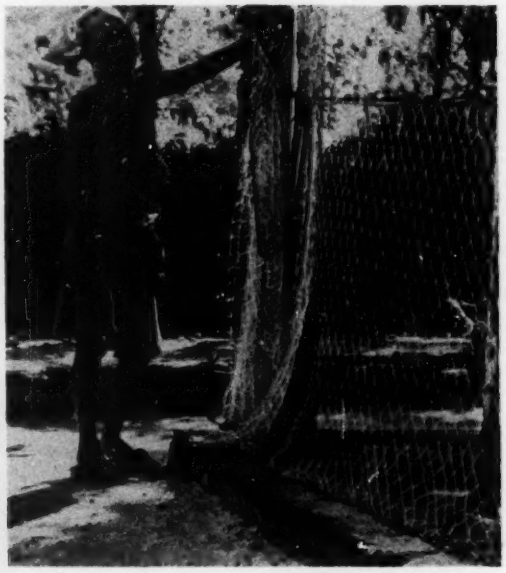


FIG. 7. Une Ishito tying wooden floats along top of fish seine. The seine is stretched between the posts supporting the front of his dwelling roof. Note the raised floor of the house and the stone blocks beneath the posts. Note also the row of cut coral stones so arranged that the rain drip from the eaves falls just outside them, thus preventing the flow of water beneath the dwelling. The beach sand spread over the yard and the coral compound wall are typical.

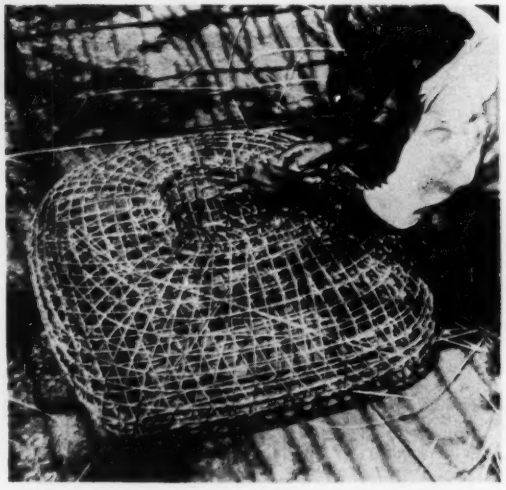


FIG. 8. Old man fashioning fish trap of bamboo strips.

rice harvest, tiny fish are taken in the paddies. Finally, as a technique of distinctly minor importance, fruit, bark, and grass poisons are occasionally introduced into the tiny streams in the vicinity of Kabira to stupify their small fish.

GATHERING

To the roster of cultivated foods enumerated above may be added a number of wild edible plants and plant products which are gathered in considerable quantities in season: papaya; guava; small, sour tangerines; pandanus hearts, a highly esteemed ceremonial food; cycad nuts, which, having been removed from their hard, red-orange shells, are allowed to mold in leaf-covered baskets, thoroughly washed in a flowing stream, and pulverized into flour for winter consumption; and mushrooms. Apart from these edible forms, wild nonfood plants are collected for a wide variety of uses. Among the most important of these are timbers and poles for building construction, long and tough vines for weaving basketry and binding house beams, thatch for roofing, palm and other bast fibers for cordage, palm leaves for rain gear, herbs for medicines, roots and bark for dyes, firewood for the cooking hearths, and grass for animal fodder. The gathering of native vegetable materials in the mountain forests occupies a part of almost every average day. Beyond question, village life would be fundamentally different without this nearby source of raw materials.

The sea, too, is not overlooked. Seaweed is gathered to add its savor to the family menu. Crabs and shellfish are collected by women, especially the older group, along the ocean shore and by men from the reef and lagoon floor. In the spring large nests of sea-turtle eggs are occasionally found on the sand beaches.

HUNTING

No form of hunting is engaged in today. In earlier days, however, when wild pigs were numerous in the neighboring mountains and constantly menaced the crops, these savage swine were hunted down by groups of men, armed with spears and aided by dogs. At times they were also trapped in deadfalls. No recollection of the use of the bow and arrow in this or any other connection could be uncovered. Rats are neither trapped nor caught in other ways despite their exasperating depredations in the food storehouses. Birds, both native and migratory, are considered too wary to be taken; hence crows, ubiquitous, bold pilferers, are a constant annoyance to which, nevertheless, the Kabirans have become resigned.

ANIMAL HUSBANDRY

Of the several domestic animals of Kabira the small black pig is by far the most important economically. Though occupying no special religious position, one or two of these epitomes of obesity are kept by about half the families of the village. Their care places a great burden upon the women of the household. First, they must be vigilantly protected from the weather in small tile- or thatch-roofed, stone structures behind the dwelling. Secondly, they must be fed twice daily a specially prepared, hot broth. This nutritious substance has for its base mashed, steamed sweet potatoes and boiled sweet potato vines. To the liquid are added as fortifying ingredients small amounts of crushed crabs, special herbs, small fish heads, or the remains of the family's meals, all such solids, however, being strained out with scrupulous care before the soup is presented still steaming to the swine. A pig is killed under the direction of a skilled but unpaid butcher. It is dispatched without ritual behind the owner's house, scalded with a solution of water and wood ashes, scraped chalk-white, and butchered beside a town well or on the bay shore. The flesh is in part consumed by the household with the assistance of its relatives and friends and is in part sold to neighbors.

FIG. 9. Kishimoto Kana unloading bundles of millet from his horse in front of his dwelling. The size of the animal, typical of Kabiran equines, may be judged from the stature of the man, which is 62.5 inches.

The native horse, a diminutive animal ranging in color from buckskin to chestnut, is born on the community range. When old enough to work, stallions are generally brought home to the compound, whereas mares, branded with the owning household's ear cutmarks, are left on the range to graze and breed. The stallions are fitted with a simple double-stick headstall, without a bit bar, and are tied at night in a thatched shelter behind the household dwelling. These animals are sometimes ridden, either bareback or with a wooden saddle, and are occasionally used to carry light burdens bound to a pack saddle (fig. 9). On the other hand, they are never hitched to plows, and, save on extraordinary occasions, never draw vehicles. Their life, on the whole, is one of supreme leisure as befits their status as an important prestige symbol.

Cattle—black, undersized, tractable creatures—are owned in small numbers by wealthier households. Bulls, never castrated, are employed not only to carry light burdens but also to pull plows (fig. 3) and occasionally to move the few carts existing in the village. As with mares, all cows have their ears slashed with their household's brand and are left free to roam the range. The carabao is only now being introduced into Kabira; because of its superior abilities as a paddy field work-animal by virtue of its greater strength, stamina, and broad feet, it is usurping the traditional position of the bull.

Goats, multicolored dwarfs, are eaten but not milked, save when the occasion demands a few drops of the liquid for administering to infants as medicine. Once beyond the harmless kid stage, goats are kept perpetually tied under a shelter in the rear of the dwelling and are fed vegetable refuse and mulberry branches broken from trees along the compound wall. Chickens are kept only for their eggs and meat, not at all for divinatory purposes; though running freely about the house yard by day, they are usually penned up at night in a special bamboo and thatch hut in the rear of the family dwelling. Cockfighting, like bullfighting, is not a Kabira practice. Dogs are numerous in Kabira. Vicious, mangey scavengers, neither petted nor cared for in the slightest, they roam nervously and hungrily through the village paths and yards until the arrival of winter ushers in the dog-eating season, when they may be killed and served, though their flesh is widely regarded as the least palatable of all animals. Cats, in contrast, are rare, despite being generally admired for their abilities as rodent catchers. Ducks were introduced in the late 1940's, but still waddle about in only three compounds of the community. Silkworms, on the other hand, are widely raised, their care being entrusted to the women, although they too first appeared in Kabira not many years ago. Hatched on trays stacked within the house or storehouse, the soft, white caterpillars gorge upon mulberry leaves until they spin their cocoons, which are either sold intact to Shika merchants or are unwound and spun into thread by the women of the household.

FOOD PREPARATION AND CONSUMPTION

Through a continuous utilization of the various techniques of food acquisition, the average Kabiran family appears to maintain a fairly adequately balanced diet and an ample food supply of considerable variety. Fish are eaten by most families three or four times a week; meat appears in the menu less frequently. Meat and fish, being both nonseasonal—hence available fresh yearround—and difficult to preserve, are normally eaten fresh. In contrast, many vegetable foods of the grain and legume classes are processed in large quantities to last months by being thoroughly sun-dried in the compound front yard. To desiccate these edibles properly is a tedious task, requiring constant attention on the part of the household women to guard against sudden showers no less than the thievery of crows and yard fowl. Once dried, these provisions are stored for use until the next harvest brings in a new crop. A few winter vegetables, such as the large white radish and bulbs of the garlic type, are preserved in brine. Soy sauce is prepared in every household kitchen and is kept for daily use through the following months.

Leafy vegetables, fish, and a few other foods are occasionally eaten raw. Most viands, however, are cooked before being served (fig. 11). Methods of preparation in common use include boiling (meat, vegetables), roasting (fish), steaming (sweet potatoes, rice) and frying (meat, fish, vegetables). Drinks, other than water, are limited to tea before and between meals, soups in great variety as an integral part of the repast, and sake, locally brewed from rice and sweet potatoes, on special evenings and festive occasions. A mildly alcoholic beverage (*mišagu* (K)), which earlier enjoyed the position now assumed by sake and which survives today primarily in ceremonial contexts, is prepared by

chewing rice, ejecting the masticated pulp from the mouth, and allowing the resulting concoction to ferment for several days in a tightly stoppered vessel.

Three meals a day are usual. The first, early in the morning before the day's work is begun, and the last, after the labors are over and darkness has fallen, are hot meals whereas the noonday lunch, often eaten in the fields, is generally cold save for the pot of hot tea (fig. 19).

THE VILLAGE AND THE COMPOUND

As previously mentioned, Kabira consists of the village proper and of the surrounding subsistence area, comprised principally of irrigated fields, dry fields, mountain forests, the bay, the lagoon, and the reef. Like spokes in a misshapen wheel, numerous narrow paths, winding this way and that, radiate from the center settlement to make easily accessible the village wells and all parts of the encircling land and sea from which the village derives its support (fig. 15).

The general characteristics of the various ecological units within the subsistence area and the primary contributions of each to Kabiran existence have been noted. Here the structure of the village and the character of its component household units are examined.

THE VILLAGE UNIT

All Kabiran dwellings being clustered, the village is a physical unit. It is divided, however, by an imaginary northeast-southwest line into two named districts of approximately equal size. A few decades ago two additional districts, much smaller than those now remaining but contiguous to the present northwest division, were also part of the community, but this pair has been entirely abandoned. The two districts of the contemporary village have no functional significance, political or otherwise, beyond their role as occasional ceremonial units and competitors.

Each district, in turn, is composed of individual compounds, the smallest unit with territorial identity in Kabiran society. The compounds are laid out with geometric precision along narrow, sandy roads, which, running the length and breadth of the village, segment it into rectangular blocks (fig. 10). Characteristically, several compounds are ranged side by side though each one extends back the full distance from one road to the next, an arrangement correlated with the fact that every compound but one faces southeast toward the bay. In 1950 the village embraced 134 compounds, including a few occupied by two or more households and a number inhabited by Miyako or Itoman immigrants.

FIG. 10. Typical street within the village, showing the compound walls of coral stone and the line of trees that grows immediately inside them. Here mother and daughter carry the two parts of a wooden quern.

THE DWELLING UNIT

Each compound is a physical and generally also a functional entity. Except for those so recently established as still to be without all of their essential components, every compound is surrounded by a stone wall, four to six feet high, fashioned neatly of mountain coral without mortar (fig. 10). This wall affords substantial protection against summer typhoons and furnishes privacy. Moreover, giving physical bounds to the household area, it places an effective limit upon the free range of household children, chickens, and young goats, all of which enjoy the freedom of the yard, and, by the same token, throws up an effective barrier against the entrance of wandering members of other households. Around the compound along the inner face of this wall is planted a row of mulberry trees, timber trees, and papaya, each variety with its individual uses and all together serving the function of an additional typhoon defense. A single, or occasionally double, gap in the southeastern wall of the compound allows entrance to the yard. This opening is often protected, as it were, by a separate stone or bamboo "spirit wall" of greater length than the gate itself, set parallel to the front wall but back a few feet

FIG. 11. Hearth between kitchen and compound wall. The iron trade pot, resting on a U-shaped clay support, is covered with the coiled basketry lid used when steaming sweet potatoes. The imported tea kettle is wedged between two stones and the edge of the clay horseshoe. This exterior cook area is put to use when the cooking demands are too great for the kitchen facilities or when the weather is especially hot. Note the gourd dipper on the wall and, in the lower right corner, a fiber ring worn by women on the head under a heavy load.

in the courtyard. In the center of the yard stands the dwelling. Clustering about its sides and rear are the partly or entirely separate kitchen and, in all households of any substance, a storehouse, an individual or duplex pig sty, a horse and goat shed, and a toilet. Inside a few older compounds too is a deep, stone-sided well, from which water is drawn in a palm leaf or metal bucket for family use but not for drinking purposes.

The open area of the compound around the dwelling serves a variety of functions. Between the front of the house and the "spirit wall" extends a broad, bare yard, sprinkled with white sand or carpeted with short grass, where foods are spread on mats to dry. One side of the dwelling, that opposite the kitchen, is devoted to an ornamental garden of ground-clinging plants and tall leaf trees, each with some specific use such as for human or animal food, medicine, building material, or decoration for the house shrine (*tokonoma*). This garden has the further value of providing welcome shade in hot summer months. Many gardens possess a small shrine, half-hidden in the thickest clump of trees or by the base of a single large tree: before an erect, cylindrical stone a foot or more high is a sand platform upon which rests a sand-filled shell where incense is burned on ceremonial occasions (fig. 24). In the rear and on the other side of the house from the ornamental garden are the vegetable plots where are planted the savory supplements to the meals which have been enumerated above and, sometimes, the tobacco patch and grove of edible bananas. Finally, in the neighborhood of the kitchen and storehouse is the area where much of the meal preparation is carried out (fig. 11).

The dwelling itself, like the compound as a whole, varies in its pretentiousness with the wealth of the household and the length of time of its existence as an independent unit: some houses are simple two-room shelters (fig. 12) while others have ten or more rooms. For the sake of breaking away from the parental household and its tensions, a newly wed couple is content to make its first home in a most unostentatious structure with grass-thatched roof and often with walls of matted grass and bamboo in place of the thin boards which form the walls of older, more elaborate residences. As time passes and the household prospers, the lumber for the frame and walls, tile for the roof, and financial reserves required to erect a larger dwelling of greater permanence and prestige are gradually accumulated until finally the first poor home can be torn down and its finer replacement built (fig. 16). The floor of all houses, fashioned of bamboo poles, is raised on low posts and the open sections of the walls are provided with heavy wooden shutters, so placed that they can be slid shut in a moment when the family retires at night or when rain falls. In larger dwellings a polished wooden-

FIG. 12. Unpretentious dwelling compound of the Nosoko Yoboshi family.

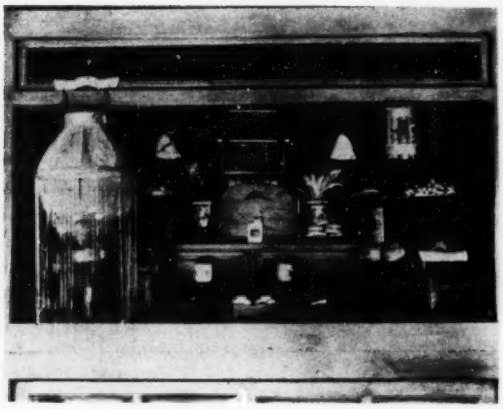


FIG. 13. *Butsudan* in main room of Kishimoto Mayu house. The offerings are those of the *obon* ceremony.

floored walkway runs the length of the front and garden side of the house. Except in the poorest homes, at least the room where the family sleeps and guests are entertained is covered with thick rice-straw mats (*tatami*). Rooms less elaborately furnished have only thin mats spread over bamboo or thin plank flooring. A shrine (*butsudan*) to the ancestors (fig. 13) and an alcove (*tokonoma*) dedicated to the spirit of the compound are always provided, usually in separate but adjoining front rooms. Certain rear rooms are invariably set aside as storerooms. The cooking room or separate kitchen hut, earthen-floored, is furnished with one hearth or with several of graduated sizes, small rice pots with wooden lids, large sweet potato steaming pots with conical, coiled straw lids (fig. 11), a variety of other cooking tools and utensils, and a store of dry firewood.

Illumination is provided within the house by crude kerosene lamps, purchased at Shika and fed with poor quality oil obtained from the same source. These have lately taken the place of simple saucer lamps. Resin impregnated pine chips and bundle torches of pine splints (fig. 6) often serve to light night work in the open air. Safety matches of Japanese manufacture, frugally hoarded, are now used instead of the palm-rotated fire drill, which is well remembered by the older generation.

As indicated previously, all structures within the compound are protected from typhoons to a considerable degree by the encircling wall and trees. Kabirans, however, do not rely entirely upon this protective barrier. Early in the typhoon season a network of vines is woven over the thatched roofs (fig. 18). Moreover, when a gale appears imminent, the dwelling, being the largest, most important, and valuable building, is buttressed by stout bamboo poles bound horizontally inside and outside the closed wooden shutters. Structures are normally kept in reasonably good repair by Oriental standards; for example, grass-thatched residences are entirely reroofed every six or eight years with the assistance of relatives and friends. Still it would be less than accurate to describe most yards as epitomes of neatness. Field produce—watermelons, squash, gourds, drying grains and legumes—as well as the work gear of the household are scattered about the compound confines. Notable among such gear are nets hung out to dry, agricultural implements, large wooden mortars and double-ended pestles, axes, and, close to the cooking area, a collection of household utensils including the kitchen pots, knives, soybean curd presses, deep baskets and shallow trays (fig. 15), dried gourd dippers (fig. 11), huge clay water jars, and bamboo brooms.

DRESS AND RELATED MATTERS

ATTIRE

During the past six decades clothing and ornament styles have passed through a complex sequence of changes. Until the close of the nineteenth century the traditional Kabiran patterns were maintained. In the area of ornamentation, for example, the backs of married women's hands were tattooed with geometric designs in deep blue, and class membership was symbolized by the material from which hair ornaments (i.e., long pins terminating in a flower design or a small, spoon-shaped concavity) were fabricated. The first change was in the direction of strictly Japanese styles. The second, coincident with the prewar Westernization of Japan, saw the introduction from Japan of certain garments of Occidental design. Finally, in the post-World War II period, the prevailing styles came once again under attack as still more Western patterns of clothing and personal adornment were introduced, an indirect effect of the American occupation of Okinawa. The present fashion is, in consequence, a mixture of true Kabiran, Japanese, and Occidental modes.

Until three or four years old, male children wear only a brief shirt, offering testimony at

this early age to the prevailing Kabiran view that, to prevent illness, the upper torso must be shielded from the sun. From this age until graduation from Middle School, boys clothe themselves in a shirt and short pants. As work garments, men to the age of about fifty wear a tightly wound headcloth, playing the twin role of sweatband and simple ornament, a short-sleeved shirt, and a breechclout with a single flap hanging in front. In colder weather short pants are drawn over the clout. Having completed their day's labors and enjoyed their nightly bath, most youths and men under the age of fifty prepare for their evening meal and the hour or two of gossip or samisen playing which normally follows by dressing in a breechcloth alone or in a clout and kimono, if the latter garment is required by the temperature or the formality of the occasion. On ceremonial days some men of this age group still cling to the traditional kimono, but others affect the Western shirt and trousers and a very few even the suit coat. Finally, men who have turned the half-century mark customarily work in their shirt and clout, removing the shirt and adding a short kimono when the weather is cool, and they almost invariably wear both clout and kimono in the evening.

While infants, girls wear only a shoulder covering like their young brothers. Soon after they learn to walk, however, they are compelled to supplement this meager upper garment with short underpants of Western style. Girls of school age don blouses and skirts as their outer garb. While engaged in woodcutting in the mountains, in tilling fields, and in other physically taxing pursuits, adult women to the age of fifty find convenient a tight-fitting shirt and long, clinging trousers or, as a more common alternative to the latter garment, a skirt, the right side of which is tucked under the elastic leg band of the underpants to bring the hem up out of the way. Frequently during the midday heat of the warmer months women wear only the lower garment whenever, as when working about the compound, their labors do not carry them out into the sun; unmarried women, however, are required by propriety to keep their arms covered to their wrists and the upper portion of their body clothed. During leisure hours, on the other hand, adult women often wear Western cotton dresses. The case is somewhat different with women over fifty: they favor the loincloth and kimono during both work hours and periods of relaxation.

Both sexes go barefoot during the workday except when coarse rice-straw sandals are demanded by the special nature of their activity, as when gathering seafood over the jagged coral shelf along the shore (fig. 6). After the evening bath, however, it is customary to slip on wooden clogs to prevent the feet from again becoming soiled.

Rain gear consists of a conical hat, a short shoulder-cape, and sometimes a skirt, all fashioned of split palm fronds. Sometimes in midsummer the hat and cape are worn by elderly men and women while at work in open fields as a protection from the intense rays of the sun.

Boys now have their hair cropped short in winter and their head shaved in summer. Without exception, men follow the Western hair style, though the top-knot was in fashion within the memory of the oldest generation. The beard is not allowed to grow beyond a quarter-inch length, its development being terminated from time to time with the aid of a dull razor or scissors. No ornaments are worn by this sex on any occasion. However, a pipe, attached to a tobacco box by a cord, is carried at the belt most of the time, and, during the hours of work, a heavy, single-edged knife, encased in a wooden sheath, is usually forced under the belt to dangle at the buttocks where it can be reached at a moment's notice.

In contrast to that of males, the hair fashion of Kabiran females differs with the age [illegible]. Young girls of the preschool and school periods wear their hair in bangs. Adult, but not old, women now crop their hair to neck length and since 1950 have begun to receive excessively kinky permanents in Shika. But women over the age of fifty continue to find attractive the traditional mode, in which the hair, uncut, is dressed with a grand bun on the back of the head and is either tied or skewered in place by a heavy pin. The earlier practice of tattooing women's hands at the time of marriage—the design was essentially identical with that of Okinawa but very different from that in vogue on Miyako—has long since fallen into disfavor as noted above, but the marks may still be observed on the hand of Kabiran women of advanced age. This older group clings also to the ancient habit of wearing necklaces of white and red seed beads.

TEXTILES

All fabric used in garments of Western cut is factory woven and is acquired from discarded American military clothing, distributed soon after

the war and now fast disintegrating into rags, or is of Japanese manufacture. In the latter instance the cloth is purchased directly from shops in Shika or from visiting peddlers who have, for their part, bought it in these city shops. Much of the traditional kimono material is likewise of mechanical loom manufacture and is secured by purchase in the city; a considerable amount, however, is still home woven on the hand loom which most houses of means possess. The belt loom, formerly the only type known, is now rarely employed, having been replaced by a more complicated, semi-mechanical horizontal loom of Japanese introduction. Home-produced cloth is woven of hemp, banana fiber, and silk, all native grown and spun, and of imported cotton thread. Kimono colors and patterns vary considerably but according to established ideas of appropriateness, specific shades and designs being assigned by custom to each sex and age group. Esteemed kimono colors are drab blues, browns, and black; the favored patterns are fine stripes or simple geometric designs of these same three hues and of white. The designs are sometimes woven in with separate threads of different colors and sometimes applied with a small brush as the fabric is being woven.

PERSONAL CARE

The Kabirans are scrupulously clean. They find the dust and dirt acquired during the course of their strenuous daily activities unpleasant and tolerable only as long as unavoidable. At least once a day each adult bathes by a well—that of his own compound, of a neighboring household, or of the village as a whole—or beside a stream. Even the youngsters are carefully scrubbed daily summer and winter. One of the commonest human sounds of the village is the wailing or irate screaming of a child in protest against the deluge of cold water it receives in its open-air bath. The hair receives careful attention; in the case of females, for example, it is dressed daily, is frequently deloused by other girls or women, and is washed from time to time in a clay and water solution.

THE ARTS

HANDICRAFTS

In Kabira opportunities for artistic expression through a manipulation of form and color are exceedingly limited. Men reveal their talents for controlling these media only in weaving and woodworking. From bamboo splints and a variety of other plant materials they weave not only basketry, where ornamental possibilities are restricted to the alternation of green and white weft elements in the basket body, but also conical rain hats, rain capes, thin spread-mats (fig. 17), and similar hand-woven objects. From wood they manufacture and repair the few pot lids, mortars, pestles, horse bridles and the like that are needed by the household. But even these meager opportunities for the display of esthetic talents are open only to older men; young men do not fashion these objects at all. On the other hand, it is the younger women, with nimble fingers and keen eyesight, who weave cloth. These weavers express themselves, with greater freedom than the men find possible, through the threads of their looms and the simple geometric designs with which they pattern their fabric. Over and above this, all women, old and young alike, have frequent opportunities to prepare ceremonial foods in varying colors and shapes and to arrange them on trays in ways that appeal to their esthetic sense.

MUSIC AND THE DANCE

Kabiran music is characterized by relatively complicated rhythm and a total absence of harmony. Instrumental music is an exclusively male accomplishment. A three-stringed samisen with a sound box covered with snake skin, an instrument imported from Shika, is played with some skill by most older men. One or two evenings a week a man commonly devotes to this instrument, strumming it in the semi-darkness of his home and singing to its sharp, vibrant tones in a strained voice traditional tunes of Yaeyaman, or at least Ryukuyan, composition. A lip-blown bamboo flute, home-fashioned, is occasionally played by young men, sometimes individually as a form of entertainment in the evening, sometimes in a group as a special feature of religious processions. Drums comprise the only other musical instrument of Kabira. Apart from the tunes which accompany all traditional dances, songs of three different classes, sung by both sexes, are recognized: lullabies, work songs, and prayer songs, each of the latter two types existing in several varieties.

The principal avenue of esthetic expression, however, consists of clever, excessively graceful posturing dances, which are thoroughly enjoyed by both performers and spectators. Both sexes are expert in their performance, the result of

conscious effort to develop their skill from earliest childhood. Always accompanied both by song and by the samisen or the samisen and drum, these dances are performed as the entertainment pièce de résistance on all more formal occasions when groups gather for special diversion. They represent in pantomime either traditions or peasant activities. The former, expressing simple animal tales, important events in the life of historical or semi-historical persons, and such sentimental themes as the sadness of the lonesome lover, tend to be slow and measured, whereas the latter are more often spirited in tempo. Dance costumes are formalized to the extent that each dance is performed with its distinctive trappings; the headdress in particular is inclined to be especially elaborate and by its shape and material reveals the identity of the animal or person portrayed in the dancer's movements.

KNOWLEDGE

MYTH AND TRADITION

A noteworthy feature of Kabira culture is the total absence of a body of mythology apart from that expressed in dance. To illustrate, no origin myths and no mythological explanations of the causation of natural and meteorological phenomena appear to exist. On the other hand, a number of traditions are current, but they seem to occasion little general interest and to be transmitted in a haphazard manner. As previously observed, most tales purportedly relate experiences of actual Kabiran ancestors and doubtless possess an element of historical truth. These narratives tend to fall into two classes, one comprising those which recount the personal experiences that led certain individuals to found Kabiran shrines (fig. 23) and the other embracing those which explain the fame of those earlier Kabirans who, because of their great reputation, became the founders of the kin groups known as *munču* (K). Proverbs, however, exist in considerable numbers; though not often quoted, they serve their chief function in expressing succinctly to children the nature of socially acceptable behavior.

NATURAL HISTORY

The Kabirans' understanding of the natural history of their area is remarkably full. Hundreds of wild plants are named and their varied uses generally known. Even a child can frequently identify the kind of tree from which a tiny wood fragment has come and, furthermore, the sex of that tree, as defined by Kabiran notions of plant sex, by observing the appearance of its wood and bark, its smell, its hardness, and similar characteristics. Fish and shellfish by the dozens are known by individually distinctive terms, and their separate distinguishing features and habits, as well as the sex differences within each type, are well recognized. Scores of localities in the environs of Kabira—islands, beaches, hills, paddy areas, dry field districts, village wells, and so on—are designated by name and are so referred to in everyday conversation. Although some of these geographical terms are plainly descriptive, the meaning of most is obscure. Indeed, the term "Kabira" illustrates the obscure type: although the village name is now written with the Japanese characters for *kawa* (river) and *hira* (plain), it is not a Japanese word but a Japanized version of the dialect term *kabira* (K), of unknown meaning, by which the villagers refer to their community.

CALENDAR

Until recently Kabirans possessed a rather extensive astronomical knowledge. Many constellations were recognized and named. Among them the Pleiades were particularly important in that their changing position was the regulating mechanism of the agricultural calendar: their appearance at dusk on the northeastern horizon marked the time once again to sow rice and begin the annual agricultural round. Knowledge of such celestial matters is now, however, almost completely lost.

In fact, three methods of regulating year-round cycles of events are still in simultaneous operation, each with its own sphere of activity: (1) the old Pleiades calendar with importance in the agricultural sphere, (2) an old lunar calendar with which many of the religious ceremonies are interlocked, and (3) a newly introduced solar calendar by which the school program is regulated. The year is likewise divided into four seasons and into a series of lesser divisions which are keyed to, and designated by, the procession of natural events such as the growth and flowering of specific plants and the appearance and departure of certain birds. In addition to these minor year subdivisions which are in current use, a 24-unit division of the year is also observed. The 12 Sino-Japanese zodiacal signs, each with a dialect name, are integral to Kabiran culture. They not only group years and days into twelve-unit cycles,

but also provide the means for dividing the day, and likewise the heavens, into twelve parts. Functionally, this zodiacal configuration has important meaning as a divinatory instrument. Moreover, the zodiacal sign of the year of birth is normally stated by elderly persons and often by youths as the simplest method of indicating age.

Many weather omens are common knowledge, including a number regarded as presaging the approach of a typhoon. Furthermore, techniques are known for bringing weather changes: when, for example, a breeze is needed on a calm day, as by a woman who desires to winnow grain, it is summoned by a soft, plaintive whistle of high pitch.

NUMERICAL SYSTEM

The Kabira numerical system, like that of the Japanese, is a decimal one from the linguistic point of view. The numbers 3 and 5 frequently appear, however, as basic units, as in counting rice bundles. Numbers are believed to possess either an auspicious or an unlucky association; as a case in point, the digits 3, 5, and 7 generally possess a favorable connotation in religious contexts. Formerly amounts, for instance payments of rice tax and population figures, were recorded by means of rice-straw knot records of quipu type. Though these devices have not been widely employed since the Kabirans became literate in Japanese, the details of the system are still remembered by the older generation. The abacus, the manipution of which is taught in school, is now depended upon as an aid in mathematical computation; its use in the village is, however, of no great antiquity.

DISEASE AND ITS TREATMENT

Illness is a constant problem in Kabira. Malaria is endemic and was a particularly terrible scourge until controlled by atabrine within the past few years. Other serious fevers, filariasis, amoebic and bacillary dysentery, worm infestations, and skin diseases are obviously common, as are, no doubt, many other grave but less easily recognized ailments which are known authoritatively to be of general occurrence in the Ryukyus. Not without reason has Yaeyama earned the evil reputation of being by far the most viciously unhealthy island group of the entire archipelago.

Tradition holds that for many years Kabirans have sometimes journeyed to Shika to consult its physicians, pseudophysicians, and diviners in cases of serious illness. The tendency to make the trip has increased somewhat since the last war, the recent inauguration of an intercommunity truck service making the journey less difficult. Nevertheless, most of the ill are still treated locally, generally within the household itself, and the treatment continues to follow the traditional patterns.

Kabirans do not possess a single thorough and consistent explanation of illness causation. In general, injuries and simple ailments are believed to be of natural causation, the former resulting from pure carelessness, whereas persistent, severe, or refractory internal illnesses are considered to be supernatural in origin. For treating conditions of natural agency, a great variety of internal and external remedies are known, many, though not all, being of plant origin. The number of native plants which find use in the Kabira pharmacopoeia is very great. The knowledge of these remedies has traditionally been a possession of the men; but, inasmuch as old men are currently transmitting this technical information to their sons' wives rather than to their sons, it will soon belong exclusively to the women's segment of culture. As a supplement to the use of these herbal medications, other curing procedures, specifically moxibustion, acupuncture, and bleeding, are likewise followed. Moxibustion is thought to be helpful as a counterirritant for sprains, boils, headache, toothache, coughs, and intestinal disturbances. Acupuncture is employed to relieve internal pain either separately or in conjunction with moxibustion, although it is less frequently resorted to than the latter method. Traditionally, old men alone performed these two operations. Recently, however, a few women have begun to engage in moxa cautery but only to cure the lesser ills of their own family members. Thus a mother will sometimes burn powder on the throat of her small child when it suffers a severe cough; but she will still call upon an old, skilled male practitioner to perform the operation around the child's umbilicus to cure abdominal pain. Bleeding is practiced to alleviate severe headaches and fevers of all types, including malaria, when they are diagnosed as of natural origin. In the case of headaches, leeches from the paddies are first applied to the forehead and temples to withdraw blood, and then, should this treatment fail to bring relief, short gashes are made at each temple and over the bridge of the nose to permit free bleeding. For fevers, on the

other hand, leeches are held to be of no value; cure from these complaints is effected by making a cut on the top of the head or one on either side of the spinal column to allow blood to escape. Cupping is not a Kabira practice.

Where illnesses resist these various treatments and are, by this fact, proved to be caused by "destiny," a displeased ancestor, an envious neighbor, or a malevolent spirit, the cure is sought by totally different methods. The precise remedial procedure followed naturally varies to accord with the specific diagnosis. An angered ancestor or disgruntled spirit may be pacified by prayers and offerings or, if the patient is female, by her joining a special religious group, one of which is attached to each of the four village shrines. On the other hand, where the ailment is believed to be the result of soul loss, the stolen or errant soul may be recovered by an old member of the village acquainted with the requisite procedure, which at times consists of offering incense, food, and prayers to the toilet deity of the compound of the patient.

ECONOMIC STRUCTURE

Most Kabirans perform their daily tasks with assiduity. Their chief practical goals are phrased in terms of securing an abundant and varied subsistence, a substantial dwelling and pretentious compound, handsome horses and strong bulls and well-fed pigs, and large families and many friends. Their agricultural chores, together with the varied tasks required by the normal functioning of the household, are quite sufficient to keep them extremely busy. But over and above these chores are frequent calls for aid from kin and friends as they find themselves faced with a special ceremony, a housebuilding project, or a similar event which places them in need of broad assistance. Whether celebrated village-wide or limited to one family, ceremonial occasions also demand much time. With these regular and special responsibilities usurping most of their waking hours, their leisure moments are generally confined to an hour or two at night between the evening meal and the time of retiring.

FIG. 14. Women of Haeno Yeizo household husking rice.

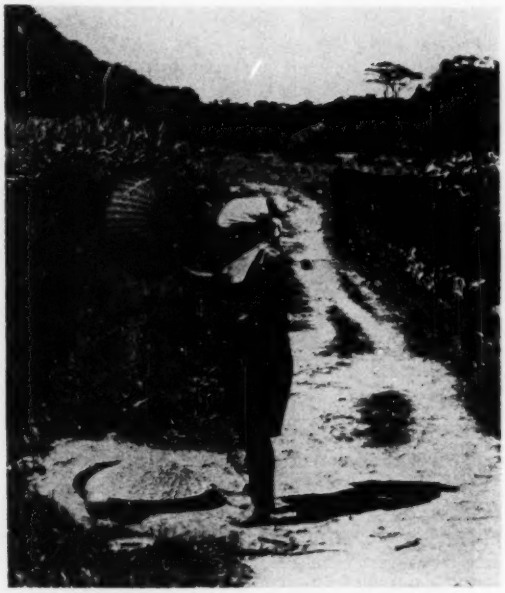


FIG. 15. Woman of Nosoko Bumpachi household winnowing rice beside path to community well just west of village. Her flat winnowing tray and gourd dipper lie on the ground at her feet.

DIVISION OF LABOR

Most of the customary tasks are apportioned specifically to one sex, the division being relatively equitable. Adult women, aided by their daughters, are responsible for most work in connection with the daily operation of the compound: they cook meals, wash clothing, fetch water, cut firewood, tend the infants and small animals, and so on

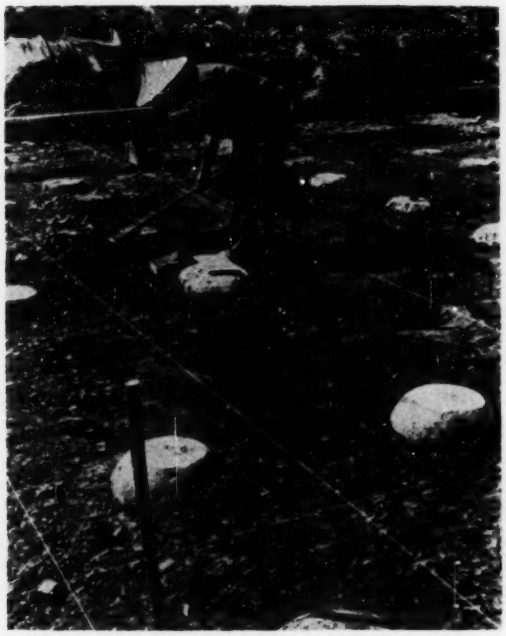


FIG. 16. Placing coral post-supports in rebuilding the Kishimoto Tōru dwelling.

(figs. 14, 15). Moreover, they contribute materially to the food resources of the household. They gather shellfish and wild land and shore plants. Likewise, they perform many of the more tedious but less taxing labors associated with the tillage of most plants, including rice. Chief among their agricultural duties is the cultivation of sweet potatoes, the planting and digging of which occupy a portion of every normal day. Women are also the weavers of cloth and the makers of all clothing. In addition, they carry most burdens from the lightest to the heaviest, usually transporting them upon their heads (fig. 10).

Men, on the other hand, engage in the more arduous agricultural pursuits: they clear new fields by the slash and burn method, construct new paddy terraces, plow the soil (fig. 3), and plant and assist in the cultivation of rice and many other crops. Men are the fishermen. As the housebuilders, they cut timbers and bamboo in the forest and roof grass in the wild plains, bring these materials to the village, shape the timbers into beams, and finally erect the structure (fig. 16). Men are the weavers of coiled, twilled, and checkerwork baskets as well as of soft bags and flexible mats (fig. 17), and they fashion fiber cordage of many sizes and materials, rolling it skillfully between their palms. Males are makers of all wooden implements and utensils such as canoes and paddles, mortars and pestles, and knife and axe handles; these, unlike pottery and metal objects, are not acquired by purchase in the city. Like their wives, men carry burdens, but in their case always on their shoulders either with or without a balance pole.

Children, even those of preschool age, aid household adults of their own sex. Perhaps because the duties of women, in contrast with those of men, are generally of a type in which children may offer substantial aid, girls contribute far more to the accomplishments of a household than do boys, have much less leisure, and appear, on the whole, to be happier and better adjusted. Old people continue to assist the household in many capacities after they have turned over the active management of the compound and fields to their eldest son and his nuclear family. Women of advanced age tend young children of their own household and of those related households without a grandmother to assume the task, aid in the fields, dry and store agricultural products, help prepare meals, care for the animals, and keep the compound yard clean. Old men devote their time to making and repairing fish nets

FIG. 17. Kishimoto Mayu weaving rice straw mat for use at shrines during *kitsugwan* ceremony.

(fig. 7), to weaving hats, rain capes, mats and baskets (fig. 8), to fashioning wooden objects and utensils, to tending the compound, and to performing a variety of similar tasks.

Little specialization of labor, beyond that by sex and age, exists. There are in the village four priestesses, four local but Shika-trained schoolteachers, and two or three carpenters, who are both poorly skilled and, by general concensus, grossly overpaid. In addition, several men are widely recognized for their ability in various commonly practiced pursuits, as in samisen playing, pig stabbing, and grass-roof laying. Such men are widely sought for their aid on appropriate occasions, receiving, however, no special payment but only reciprocal help of some sort at a later date. Similarly, some women are considered especially skilled weavers, bean-curd makers, and the like. Until 1951, when a doctor, only partially trained even by simple Ryukyuan standards, settled in the community, Kabira had no true medical practitioner other than the midwife, who first came following the war and has now left the village. No professional seers, such as exist in Shika in considerable numbers, make Kabira their home. However, one old man, crippled with arthritis, possesses several astrological volumes and is consulted by villagers needing to ascertain a favorable day and hour for a ceremony, information to help in the recovery of lost possessions, and other professional advice. There are no potters in Kabira, and the only blacksmith is a recent Miyako immigrant, though in former times skilled smiths were numbered among the more honored of the village members. Thus, for the most part, Kabirans merely attain a uniform level of mediocrity in the daily pursuits which are common to every active member of the community.

PROPERTY

Both public and private property are recognized. That of community ownership includes certain dry-field areas, the animal range, most of the mountain forests, the shallow shore waters, the community hall (fig. 18), and the four village shrine sites (fig. 21). Most private property is owned by the joint family, held in trust by its head. This category includes the land holdings with their growing crops and field huts (fig. 19), the compound with its several structures, and the domestic animals. In a very real sense, it embraces also the utensils of the dwelling, the food, perhaps even the clothing of the family members. In short, the members of a joint family own and use in common virtually all objects within its compound. All of this property with any permanence is inherited by the eldest son with the exception of whatever small agricultural plots are allotted to younger sons—none go to daughters—as they marry, separate from the parental household, and establish with their wives their own compounds.

TRADE

While actual cash in the form of United States military currency, the only legal tender, seemed rather more plentiful in Kabira in 1952 than it did in 1950, much of the trade continues to be by barter. Kabiran products commonly converted to cash or bartered for needed items include rice and pigs as the most important and, secondarily, sweet potatoes, home-woven cloth, fire-

FIG. 18. Community hall used in particular by Youth Association. The network of vines covering the roof helps hold the thatching against typhoon winds.

wood, and native-grown hemp and banana fiber. In return for these, villagers obtain small quantities of factory-woven cotton print material, metal and pottery vessels, lamp kerosene, tobacco, sake, macaroni, dried bonito, red food dye for the preparation of ceremonial foods, and the like, most, if not all, being imports into the *rettō*. Many minor purchases are made at the few tiny shops which are operated as adjuncts to Kabira homes; more important transactions are carried out in Shika by the buyer himself on an occasional trip to this center of Yaeyama life; and a few items are acquired from women peddlers from Shika who occasionally bring their wares to the village to spend a few hours in the pursuit of profit. The meager funds obtained by the procedure mentioned above and the simple pat-

tern of sale and purchase described are generally sufficient to fulfill those requirements of the villagers that cannot be met within the community. Only rarely are more funds needed by the household than it has concealed in its secret hiding place within the dwelling. At such critical periods the required amounts can usually be borrowed from closely related families, avoiding in this manner the necessity of obtaining loans from city usurers at exorbitant interest rates.

TRANSPORTATION AND COMMUNICATION

Despite the proximity of the sea, Kabirans are in no sense boatmen, let alone seafarers. The sole watercraft is an indifferently made pine dugout,

FIG. 19. Field hut of Kishimoto Mayu household. Here, in the shade of a tree, household members prepare their midday tea, rest from the heat of the sun, and escape a sudden violent shower while working in their fields nearby. Here also, under the dry thatched roof, harvested crops are stored temporarily until they can be brought to the family compound within the village. Note the millet bundles, grain heads downward, just inside the doorway. A large Tridacna shell, employed as a water container, lies on the ground to the left of the hut.

unequipped with outriggers or sails. Sometimes a man poles and paddles his dugout across the bay or a short distance up the shallow lagoon between shore and reef to reach his more remote rice paddies or to float home timber he has cut in distant mountain forests. But beyond this, water transportation is scarcely used in Kabira. Until the early postwar years, land travel was hardly more important; until then only narrow paths connected Kabira with other communities, including Shika twelve miles to the south. Travel was by foot and horseback under usual circumstances, by litter in the case of the ill, and by sedan chair for people of position. Recently carts drawn by horses and bulls have appeared in the village to lighten the household labors. In the postwar period, the trail to the south was widened, and in 1952 two ancient trucks, kept in operation by the consummate mechanical skill and infinite patience of their drivers, made almost daily trips between Shika and Kabira. With the advent of this truck service, contact with the city has become far more frequent and extensive than previously, new ideas reach Kabira more quickly, news spreads more rapidly, and the village is gradually losing its former isolation and relative self-sufficiency. Moreover, this change is having its effect upon the community members themselves. The younger generation, especially second and subsequent sons, is being attracted to Shika by its bustle, excitement, and metropolitan character as well as by the possibility of securing a better living there through shop-keeping than could be managed in Kabira by tilling the meager plots which fall to their lot by inheritance.

Kabira has its own post office, a cubicle in a room of a private dwelling, where the customary business of such a center is conducted by a full-time postmaster, an employee of the Ryūkyū government. But the amount of correspondence which passes through this office is inconsiderable: incoming mail averaged 133 letters monthly in 1952 while the outgoing amounted to only 33 items a month, even if the uncommonly heavy New Year's mail be included in both computations. Here too is located the single telephone of the community, an exceedingly unsatisfactory and unreliable postwar innovation which permits communication with Shika more often in theory than in practice. Telegrams are dispatched from and received in this same office; in the latter instance the message is telephoned to the postmaster who, having reduced it to writing, delivers it to the addressee.

In 1952 four single-page newssheets, published five times weekly in Shika and selling for 40 yen (33 cents) a month, circulated in Kabira. Approximately 30 households, fewer than one-fourth of the total number in the village, subscribed to one of the four. Even within the subscribing compounds the reading audience is very limited; for in each of these households hardly more than one adult has been exposed to enough schooling and has retained enough education to read the newspaper without painful study.

SOCIAL UNITS

KINSHIP

In Kabira kin affiliation is an interpersonal bond of fundamental importance, carrying, beyond question, more weight in most social situations than mere friendship or proximity of residence. Consanguineous relationship is formalized terminologically in a system which most resembles the "Hawaiian-type" of Lowie [9] from the point of view of the parent and parent-sibling terms, and the "Eskimo-type" of Murdock [10] from the point of view of the first-cousin terms. Though basically simple and bilaterally symmetrical, it is notable for the complexities of its sibling classification and for the extent to which term referents overlap. Only the following few observations with regard to this terminology can be made here.

(1) No terminological distinction is recognized between patrilineally and matrilineally related kin, even though a female technically abandons her own kin groups upon marriage and joins those of her husband.

(2) In the case of relatives younger than the speaker, kin terms are used only in reference, the personal name being employed in address.

(3) For all generations above the speaker, the terms differ with the sex of the relative addressed or referred to but in generation levels below the speaker they are generally identical for both sexes.

(4) Formerly one set of terms, including at least those for father, mother, grandfather, and grandmother, was employed by families of noble rank while a separate, linguistically unrelated series was current among people of commoner affiliation. To some extent these distinctions are still followed by descendants of the two classes.

(5) A single term denotes father and father's and mother's older brothers, whereas the younger brothers of both parents are known by another single word. Similarly, mother and the older sisters of both parents are designated by one word, whereas the younger sisters of father and mother are together denoted by a different term.

(6) Sibling terminology is especially complex. A fourth son uses a different word—but the same one in each instance in reference and address—for each of his three older brothers and a distinct but parallel series for each of his three older sisters; he employs, nevertheless, a single relationship term to refer to all younger siblings whatever their sex, although addressing them with their personal names. A girl makes use of a set of terms for her three older brothers that differs from that used by her male sibling of equivalent position within the family, but employs the same terms as his when addressing or referring to her older sisters and when referring to her younger siblings of both sexes.

(7) Notable is the tendency to disregard, for purposes of address, the formal complexities of the system and, by kin term extension, to identify more distant collateral relatives with more closely related kin of the same generation. Thus, though a single special reference term exists for first cousins of all four types, no sex distinction being observed, they are addressed either by sibling terms or by personal names after the procedure followed in the case of actual siblings. This may be but one reflection of the social importance of possessing as large a close family as possible, the fiction of term identity being employed to draw these more distant kinsmen within the bounds of the tighter family group.

(8) Similarly, affinal relatives are not differentiated from consanguineous kin in address.

(9) Certain formalized interpersonal behavioral patterns exist between relatives of specific categories, yet they appear to be fewer and weaker than might, at first blush, be expected from the complexities of the terminological structure.

KIN GROUPS

The basic social units in Kabira are kin groups, bonds of biological affinity being the strongest of all formal ties between individuals. The nuclear family is, of course, the smallest such unit. Ideally, however, this minimal group does not exist or function as an entity in itself, for it is submerged within a kind of patricentric "joint family." At its maximum point of development this joint family embraces a man and his wife, his aged parents if he himself is an eldest son, his own eldest son and growing family, and all of his other children, real and adoptive, as long as they remain unmarried. This is the smallest significant unit in Kabiran society. With the important exception of sex expression and the perpetuation of the family through reproduction, it assumes most functions normally assigned to the biological family. It owns the substantial

[9] *Cf.* Robert L. Lowie, *Social organization*, 63, New York, Rinehart, 1948.

[10] *Cf.* George Peter Murdock, *Social structure*, 223, New York, Macmillan, 1949.

property, as mentioned elsewhere; it cares for and trains the children; it supports its aged members; in its hands rests the performance of the ceremonies to the immediate family ancestors. It resides in a single dwelling within the four walls of one compound. It is generally identical in composition with the "household," the coresident group. Occasionally, however, the household includes a more distant relative or perhaps even a temporary hired worker, a rare luxury in Kabira. Consequently, the joint family and the household must be recognized as distinct social segments. The household is the work group, tilling the fields and performing its many other tasks as an integrated labor unit for the primary benefit of its core joint family.

From this joint family and household younger sons depart as they marry, form their own family of procreation, and establish, with the help of the parental joint family and other close relatives, their own compounds apart from their family of orientation. Upon marriage, daughters leave home to join their husbands. Yet, because most marriages are within the village, all sons who depart from the parental compound, and even daughters to some degree, remain within the orbit of their family of orientation, returning to its residence to participate in special ancestral rites, seeking help from it, and giving aid to it from time to time. This larger group of patrilineally related joint families comprises a kind of "extended family" or "sublineage." While much less important in the social system than its individual component joint families, this unit is not without function. It is the sublineage which owns the great tomb (fig. 25) in which are laid to rest all of its members. Likewise, as remarked above, the sublineage functions as a cooperative unit in the performance of ceremonies to the common ancestors and in those unusual enterprises of the individual households which require many hands. Among its joint families occurs a good deal of borrowing of the more expensive domestic and agricultural equipment. Similarly, funds needed to finance those activities on the part of a single household which are considered worth while by the sublineage as a whole are ordinarily obtained on loan from member joint families.

Above these two basic groups of biologically related individuals are still larger patrilineal social units of far less functional importance. Among these is the *yaa* (K), a kind of "lineage" which is sometimes, by chance, identical with a single sublineage but more typically includes several sublineages whose actual relationship to one another is always known. Every Kabiran joint family belongs to a *yaa*. Each *yaa* has its own dialect name; except where the *yaa* is of noble ancestry, this designaton was used as the basis for the Japanese family name which each *yaa* in Kabira acquired not many years ago.

A kin unit of still greater magnitude, which resembles in many respects a week, agamous "patriclan," is the *munču* (K), of which five of Kabiran origin still persist in the village. A *munču* is composed of several *yaa* which by tradition, though the fact is now not demonstrable, have descended from the famous founding ancestor of the *munču* unit. Not all *yaa* are members of *munču*, however. Most male members of each *munču* indicate their affiliation by possessing in common the same element as the first unit in their given name. Whenever possible, all members participate in the annual pilgrimage to the shrine of the ancestral founder. All five present *munču* are regarded as having originated about four centuries ago.

CLASSES

Formerly, when Kabira was within the Okinawan kingdom, the population was divided into two endogamous classes, nobility and commoners. Most *yaa* belonged to the latter group. *Yaa* of noble rank became established in Kabira either by being introduced from elsewhere, the original immigrant founder generally having been assigned to the community as a government official, or, in the case of native families, by a nuclear male member being elevated to exalted rank by the royal court as an expression of gratitude for exceptional service. All nobles were village officials or were farmers like the commoners, in the latter instance often being actually poorer in fields and property than many of their low class covillagers. Nevertheless, they occupied by law a preeminent position and consequently were deferred to by people of low birth, possessed the right to wear hair ornaments of precious metal and other distinctive dress, and enjoyed the privilege of holding government posts. If the general view of contemporary Kabirans of commoner ancestry is correct, the highborn characteristically felt that physical labor, beyond the unavoidable, ill befitted their station, an attitude which their present detractors eagerly ascribe to sheer laziness. The noble or commoner affiliation of every *yaa* is still remembered. Even so, earlier status differences

appear to have no significant present reflection in differential behavior. No groups comparable to the Japanese *eta* and other "outcaste" classes existed in Kabira.

SODALITIES

Only two mutual-aid associations now persist in the village, though formerly there were a few others. One group cuts timber in the mountains for house construction and the other clears new land for paddies. Lottery associations are formed from time to time but soon dissolve; they are patently unimportant in village life. A few community-wide sodalities have appeared within the last few decades as the result of Japanese influence. These include in particular the Parent-Teacher Association, Women's Club, Youth Association, and Agricultural Association.

POLITICAL SYSTEM

POLITICAL STRUCTURE

Territorial bonds are as weak within the community as relationship ties are strong. Technically, Kabira is a political subdivision of Ishigaki Shi, the administrative unit which embraces the western half of Ishigaki Island. Kabira excepted, the villages of this *shi* are concentrated on the southwestern end of the island. They include as their dominating member the city of Shika, which, with its 18,000 inhabitants, is the population and trading center of the *rettō*. Kabirans are allowed a vote in *shi* and Ryūkyū central government elections. Nevertheless, being separated by twelve miles of mountains, forests, and fields from the rest of the *shi* population, they often neither know the officials whom they elect nor see them once in their entire term. Understandably, they are little benefited by the *shi* government, whose chief interest lies in Shika and the populous area around it. Several village officials, however, are appointees of the *shi* administration: a *kuchō* who collects *shi* and central government taxes; a policeman, whose duties are described below; two health inspectors with incidental and vague responsibilities; a fire chief, who, occupying a position established about 1948, directs at times of conflagration the volunteers who man the newly acquired hand pump; and several schoolteachers, who, unlike all the preceding, are for the most part non-Kabirans.

Despite its membership in this larger political entity, Kabira is in all essentials an internally governed community, as self-contained administratively as it is economically. The actual administration of the village is carried out by the residents themselves through (*a*) their two assemblies, one composed of all men of productive age and the other comprised of all women within the same age limits, and (*b*) more directly their unpaid officials of both sexes which these assemblies elect yearly. The elected male officials comprise the village leader and vice-leader. This pair conducts the community business with the assistance of two youths who collect the village rice and money taxes and then disburse these funds in community projects under the guidance of their superiors, of two younger lads who serve as general assistants and messengers, and of a consultative body of ten capable men, from which the leaders seek advice when especially perplexing problems arise. Paralleling this male administrative structure is a second one of female officials, the leaders being chosen by the women's assembly. Their duties involve the supervision of the women's community activities, such as the greeting and entertaining of visiting dignitaries and the arranging of the public dances and other diversions which accompany village ceremonies.

Other duties of a village character, as the maintenance of the roads, are distributed among the few community-wide sodalities mentioned above, or are the responsibility of the several old religious groups discussed below.

SOCIAL CONTROL

Adherence to the social norms is accomplished mainly through the agency of the various kin groups. The pressures employed by kinsmen to effect this control upon the young include praise, stricture of a direct or sarcastic nature, unflattering comparison with others of the same sex and age level, and physical punishment which, though invariably light, is so rare as to be frightening to the child. In the case of adults, the force is primarily that of subtle and occasionally outspoken criticism. The joint family and sublineage, jealous of their reputation in the community and sensitive to external censure, exert a strong influence upon all their members to act within the bounds of propriety. The individual himself realizes clearly that his right to call upon his kinsmen for aid is contingent upon his fulfilling his obligation to act so as to bring prestige to his kin groups. It is not surprising, therefore, that antisocial behavior is virtually absent in Kabira: indeed, anything more serious than petty

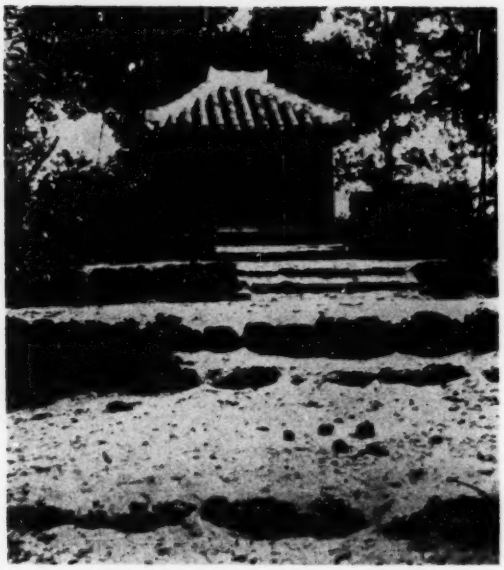


FIG. 20. Buddhist Kwannon temple on height at eastern edge of village overlooking Kabira Bay. The approach has recently been cleaned by the school children and spread with fresh shore sand.

theft is all but totally unknown. It cannot be denied that most Kabiran men enjoy their native-brewed sake. Yet very few drink to excess and even these tipplers do not attain a point of complete inebriation. While Miyakoans, according to reputation, are accustomed to drink themselves through a violently argumentative mood into a full stupor, Kabirans merely become exhilarated and then, singing cheerfully, weave their way home along the darkened roads. The stationing of a policeman in the village shortly before 1952 was intended only to control the pernicious use of explosives by Itoman fishermen, a situation which this officer, without boat, binoculars, and other equipment, is powerless to remedy.

RELIGION

The institution of religion, with its several agent groups, ceremonial calendar, specific rituals, and so on, is unquestionably the most intricate complex of the whole culture fabric of Kabira. Nothing more than a description of its essential points can be attempted here.

No elements of the formal State Shintoism of recent Japan seem to have reached Kabira. Buddhist influences, on the other hand, may clearly be seen. Physically, they take the form of a single Kwannon temple (fig. 20), which, however, is ignored save on two fixed days each year when it is visited by a few Kabirans for brief prayers. Aspects of Buddhist rituals are evident primarily in the death and anniversary rites. The philosophical tenets of this religion, its doctrines of moral behavior, such as its proscription against the taking of life, its mysticism, and its pantheon are all unknown to the villagers. Nevertheless, all Kabirans identify themselves as Buddhists.

The basic practices of Kabiran religion, however, revolve about the belief in, and worship of, a large number of localized spirits with specific powers. Most of the powers are of a diffuse agricultural character. The few nonagricultural deities—the moon deity, the various spirits of the compound, the village well spirits, the deity of the waterfall, and the like—exert but a limited influence upon village life. Fearful supernaturals, in particular diaphanous female ghosts in human shape, are occasionally observed by night in their individual retreats; but, because to witness them normally has no permanent, serious consequences, these beings of the nonphysical world are relatively unimportant.

THE SHRINE AND ITS PERSONNEL

The only substantial religious structures in the community are the four shrines where much of the ritual life occurs. Each shrine is built in

FIG. 21. Entrance to shrine at foot of Nakamamurī. The sylvan character of the shrine area is typical.

FIG. 22. Typical shrine building. Within this structure the various utensils employed in the ceremonies are stored and certain of the ceremonies themselves are performed.

a dense sacred grove where even the cutting of a twig must be preceded by a special petition to the resident deity. A neat path leads from the main road beneath a small wooden torii through the trees to an open area (fig. 21). There stands a small, unadorned building with wooden walls and floor and a tile roof (fig. 22). Its interior is bare except for one corner in which is built a small shrine recess to receive religious offerings and below it a closet to hold the sacred utensils. Behind this building stretches an elevated terrace, carpeted with grass or white sand, where the old men gather to participate in certain ceremonies and the families who are most closely associated with the shrine congregate to enjoy the entertainment which follows some rituals. This terrace is terminated at the side opposite the building by a high stone wall which, crossing the grove from side to side, separates the common meeting place from the sacred area deep within the trees where the spirit resides (fig. 23). The wall is identical in materials and construction to those around dwelling compounds, save only that it is provided at its midpoint with a small opening with a single stone lintel above and a stone step below. From the hallowed area behind, all males are excluded except, under special conditions, the direct descendant of the shrine founder. Within the area, under the dense shade of large trees, is the simple altar, a series of flat, steplike stones upon which rest incense bowls and, on ceremonial occasions, food offerings.

Each of the four shrines boasts a distinctive name and a different traditional origin. One (fig. 21) marks the locality where centuries ago a young Kabiran woman saw evening after evening a mysterious light rise and fall between the trees and the Pleiades, the most important star cluster in the heavens as noted above. A second was built by a Kabiran man in fulfillment of his promise to the deity of a Miyako shrine for having granted him a safe sea journey home. These four shrines are ranked in accordance with their current importance, which is apparently identical with their relative antiquity.

Each shrine has its own central joint family (*mutuyaa* (K)), whose head is the patrilineal descendant by strict primogeniture either of the father of the woman shrine founder or of the man who himself established the shrine. This person, termed *kammangaa* (K), has certain ritual responsibilities to discharge and, as already noted, is the only living male permitted to enter the sacred area behind the wall. To this one family or, if this is impossible, at least to its sublineage belongs the priestess (*cīkasa* (K)) who officiates at all sacred functions of the shrine. Ideally, she inherits the position by being the eldest

FIG. 23. Gateway in coral stone wall leading to deeply shaded, inner sacred area of shrine where priestesses perform their ceremonies. This is the only shrine lying within the perimeter of the village proper.

daughter of the *kammangaa* or, should no such potential heir exist, by being the closest female kin by patrilineal reckoning to such a person. However, if no definite heir is clearly designated by the inheritance system, a successor is determined by sacred lot from among the sublineage members. The four priestesses of the shrines are by far the most respected individuals in the village, even though their power is entirely religious. Their duties are onerous; they must not only lead the community in all village rites but also perform individually at their respective shrines the many rituals, numbering as many as several each week, in which they alone participate. They must memorize the sacred prayers, a task so great as to terrify women who, by virtue of their birth, are potential *cīkasa*. The priestesses may marry; indeed, almost invariably they are mothers before assumption of the *cīkasa* role. Even after their elevation to the position they continue to lead normal lives, cultivating fields, visiting neighbors, bearing children, and performing household duties to the extent that they find time for such secular pursuits.

Each shrine possesses likewise a group of women acolytes (*tiinarabī* (K)), each of whom, when ill with a perplexing and unyielding internal ailment, joined this group on the advice of a Shika soothsayer and promptly became cured of her deity-caused illness. To each shrine *cīkasa* is assigned a male assistant (*suudai* (K)), who, in consultation with his fellow *suudai*, schedules the ceremonies as tradition dictates and makes all arrangements required for their observance. These four *suudai* are aided by three youths (*murabusa* (K)); the latter are responsible for the upkeep of the shrine areas, for carrying the sitting mats and ritual gear from one shrine to the next in the village ceremonies, for notifying each village household of the day upon which an approaching ceremony is to be held, and for carrying out similar shrine tasks.

Several special religious groupings, composed of lineages (*yaa*) whose membership in their respective units continues, of course, in a patrilineal manner, also exist in Kabira. First, each shrine has its own congregation; to one such congregation every Kabira *yaa* belongs. Each congregation celebrates certain rituals independently at its shrine. In the second place, seven patrilineal religious groups known as *tuniyaa* (K) now exist in the village, each with its own central joint family to direct its activities; every *yaa* is a member of one *tuniyaa*. These *tuniyaa* function but twice a year as indicated below. Finally, there are six patrilineal cult groups, each with its own deity (*øuyan* (K)) and nuclear joint family (*mutu nu øuyan* (K)); again every Kabiran *yaa* has membership in one of these and so enjoys a specially close relationship with the deity of that cult group. Only in the house building and marriage ceremonies, however, is the family's association with this deity mentioned.

MINOR SPIRITS

In addition to these important deities of the village shrines, lesser spirits abound. Many are localized in small, dense groves where their shrines are built and are believed to be lineal

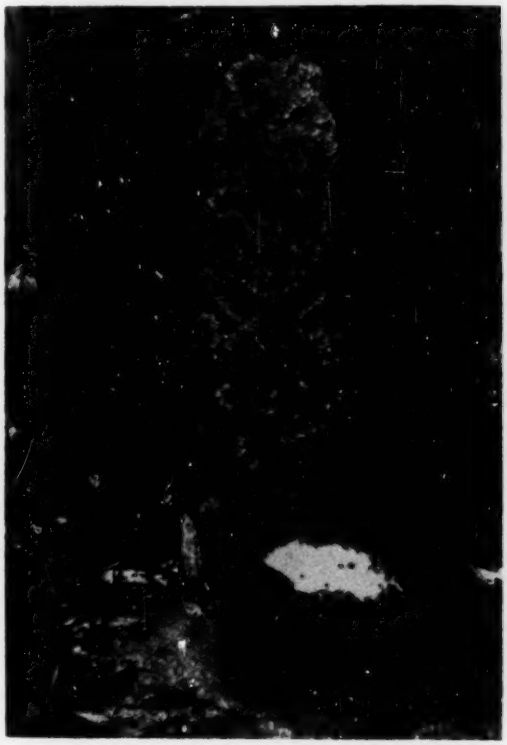


FIG. 24. Garden shrine within Maaji Masawo compound. This vertical stone, termed *bičuru* in Kabiran, is about three feet high. Before it is placed a low stone bowl—rather than the more common shell—filled with white beach sand. Into this sand burning incense sticks are thrust when offerings are made to the spirit of the compound premises, to whom the shrine is erected.

descendants of the deities of the main shrines; like human lesser sons, they have been forced to leave the parental dwelling and establish themselves in separate quarters. The limited ceremonial needs of each of these spirits are administered to by the priestess and other officials of that main shrine to which the spirit traces its parentage. Still more minor shrines, of joint family ownership and exclusively family interest, are scattered about in the paddy fields and under great trees. Within the dwelling compound, too, reside many deities: among these are the spirit guardian of the entire compound, localized in the house shrine (*tokonoma*); the dwelling deity proper, permanently stationed in the main post of the dwelling beside the ancestral shrine (*butsudan*) (fig. 13); the fire god, symbolized by three triangularly arranged stones in the kitchen; and the deities of the storehouse, the well, and sometimes even the toilet. Finally, within the ornamental garden of many of the older compounds of the village a spirit dwells in the secluded shrine referred to in an earlier section (fig. 24).

CEREMONIES

As might be expected from the existence of this spiritual pantheon, the ceremonial life of Kabira is complicated. Ritual events are keyed to the lunar calendar in a more or less definite way and each rite has its special characteristics, including its traditional foods. Certain ceremonies, in particular those honoring the household ancestors, are fixed in their time of occurrence to a specific day of a definite month, whereas others, especially those associated with rice cultivation, are celebrated on a day which, being somewhat free to vary from year to year, must be determined by the *suudai* in conference.

Rites of the former class include the following:

(1) 1st lunar month, 1st day. Thanksgiving prayers and offerings are made to the shrine[11] deities by the priestesses and old men, as well as to the joint family ancestors and compound spirits by the household. Feasting follows.

(2) 1st month, 16th day. Food and prayers are offered at the ancestral tombs.

(3) 3rd month, 3rd day. Food offerings are presented to the family ancestors, the compound deity in the *tokonoma*, and the fire god. All people congregate on the shore to catch and gather seafood as an outing.

(4) 7th month, 7th day. Prayers and food are offered to the family ancestors.

(5) 7th month, 13–15th days. The ancestor festival: elaborate food offerings are placed before the family ancestors, and prayers are directed to them by their descendants now residing in other households.

(6) 8th month, 15th day. Food offerings, including phallus-shaped rice cakes, are made to the family ancestors and to the lunar deity in the evening.

(7) 9th month, 9–10th days. A thanksgiving ceremony: acknowledgments of gratitude are made to the shrine deities by the priestesses and the old men. Special emphasis is placed upon the sweet potato in the prayers and food offerings.

In contrast to the rituals of the preceding list, the following ceremonies are not fixed by tradition to a specific calendric day:

(1) 2nd month. Food and prayers are offered to the family ancestors in supplication for health and a good harvest.

(2) 4th or 5th month. A prohibition against going to the mountains and shore is observed for three days. This period is followed by the first-rice ceremony in which newly reaped rice is offered with expressions of gratitude to the shrine deities and the family ancestors.

(3) 6th month. In the morning a thanksgiving ritual for the rice harvest is held at the shrines by the priestesses and old men. In the afternoon all families feast at their own shrine. In the evening families gather for relaxation at the home of their shrine *mutuyaa*. The following night the *tuniyaa* ceremony takes place as described below.

(4) 8th month. The priestesses and old women pray at their individual shrines through one night and the following day and night for bountiful crops, large families, and the like. The next day prayers and offerings are made at all shrines by the priestesses and old men, an afternoon of dancing and feasting is enjoyed by all the village at the highest shrine, and evening dances are held at the village hall.

(5) 9th month. A five-day ceremony is celebrated in honor of the New Year according to the Pleiades calendar. The interior of the dwelling and the compound yard are thoroughly

[11] Henceforth, as in this instance, the term "shrine" designates one or all four of the main village shrines, not those dedicated to the minor spirits.

cleaned and the village wells are emptied and scrubbed. After dark on New Year's eve a spectacular ritual occurs: pairs of men, dressed in palm rain capes and hats to conceal their identity since they represent the deities, go through the village, stopping at each compound to chant in archaic language a blessing upon the household, its crops (particularly rice), and its animals. On New Year's day food offerings are made to the family ancestors, prayers are addressed to the compound wells, and the entire compound is ritually purified with fresh shore sand. A dance competition between the two districts of the village occupies the following two days. Finally, on the last day of the period the priestesses pray at the highest shrine and, with its spirit in their company, return to the village at dusk, escorted by the older women bearing flaming pine torches, for an evening rite at one compound. This rite is designed to supplicate the deities for a bountiful rice harvest, the important winter planting being soon to take place.

(6) 10th or 11th month. A rice-sowing ceremony is celebrated. Rice cakes in mound shape are offered to the family ancestors and are exchanged with kin of other households. On behalf of the entire community, each priestess begs her own shrine deity for a generous rice crop. The rice sprouts are sown on the same day. On the evening of the next day the ritual at the *tuniyaa* is again held.

(7) 11th or 12th month. The priestesses pray at the shrines. Foods and *susuki* grass stalks are offered to the family ancestors; stalks are also placed before the household deities and pushed into the mud of the paddy fields. Everyone remains very quiet all day. Together, these acts insure a good rice harvest.

(8) 12th or 1st month. Prayers are made at the shrines by the priestesses and old men to aid the growth of the rice.

Certain ceremonies, it will be noted, take place at the shrines alone, others occur only within the compounds, and still another group includes phases in both places. Again, some involve only the priestesses, occasionally with assistants, while others require the participation of members of the joint families.

In a typical shrine ceremony of the most general type the old men gather first at the highest shrine early in the morning. While they sit as a congregation in respectful silence, the priestesses in congress, clothed in their prescribed yellowish banana-fiber kimonos, solemnly enter the sacred inner area to light incense, pray, and place food gifts before the spirit's altar. Immediately upon completion of this rite, the entire group of men and priestesses moves to the second shrine to repeat the performance, and then to the third and fourth. On certain occasions, as noted above, each family visits its own shrine in the afternoon to feast and gossip with other member families and to observe and participate in graceful posturing dances on the grass or sand terrace between the shrine structure and the stone wall. Twice a year an evening celebration is held at the dwelling of each *tuniyaa* leader: families gather at their own *tuniyaa* center, a priestess opens the rite with a prayer, all sing special songs relating to rice cultivation, and all enjoy the feast which concludes the ritual.

Besides the basic ceremonies already listed, less important public rites at which the priestesses must officiate are held at the shrine each month, excepting only the seventh lunar month when no one, not even a priestess, is allowed to enter the shrine precincts.

Frequent semi-secret or at least nonpublic rites must likewise be performed or directed by the female shrine functionaries. The following illustrate their duties of this character. On the first and fifteenth of each lunar month each priestess prays individually and alone at her own shrine. Again, five or six times yearly a priestess, aided by a specially selected man and woman, conducts an important one-day ritual to free the fields from insect pests, while all villagers avoid making loud noise. Whenever a severe and continued drought threatens the crops, one priestess, because of her learning, experience, and close personal association with the spirit world, assumes charge of a series of rain-producing rituals. These begin with three-day prayers at the shrines, pass, as the situation becomes more desperate, through a ceremony of lighting great smoking fires on the nearby mountain tops, and terminate, as a measure of last resort, in a sacred procession of old women of impeccable character to a waterfall at the head of Kabira Bay where they and the priestess petition the deity of the cascade to grant rain to the parched fields. Finally, the priestesses also play an important role in the late autumn rite of stretching rice-straw ropes across the village entrances to afford magical protection for the inhabitants against the entrance of disease.

Many ceremonies, rather different in their form and significance from any enumerated above, take place only within the village compounds or at least are carried out by each household group independently. Some, like the yearly pilgrimage to the ancestral tomb, are undertaken by every joint family on the same day. Such, too, are the brief ritual of offering incense and prayers to the household *tokonoma* on the first and fifteenth of each lunar month and the daily setting of burning incense and tea before the ancestral tablets on the *butsudan* (fig. 13). But most rituals of this kind are of occasional occurrence and of primary interest to but one household, though, in some instances, participated in by kinsmen, neighbors, and friends. Among this group of rites are those which necessarily accompany the building or rebuilding of a major structure inside the compound walls. Prayers and food are offered to the deity of the site before construction begins and by the family's shrine priestess to the spirit of the building when the framing is completed and again when the roof is laid. On these last two occasions the brief rituals are followed by fine feasts in which all who aid in the construction participate. Finally, for some years afterward simple birthday ceremonies are held for the structure. Similar construction and birthday rites are performed for tombs and compound wells. Within this general class of ceremonies of exclusive concern to a single family fall also the offerings its makes on occasion to the spirits of its compound garden-shrine (fig. 24), of its special paddy terraces (only a few wet rice fields are thought to possess their supernaturals), and of particular large trees growing on its property.

A final class of household rites, less religious in character but not utterly devoid of this element, are those which are held by each family for its own members. These include important birthday ceremonies, especially those given on the first, the forty-ninth, and every successive twelfth anniversary, which are celebrated with prayers for long life and with feasting, samisen music, and general felicitation. Marriages likewise are occasions demanding an elaborate ceremony in which fine food and entertainment comprise important ingredients. Finally, deaths and all recognized death anniversaries are observed with religious rites and often feasts by family members. Although in all these cases only one family is immediately involved, such events actually require for their proper celebration substantial aid from relatives and friends, who, of course, participate with the primary family in the rites and festivities of the day.

THE INDIVIDUAL

BIRTH AND INFANCY

In Kabira no culturally patterned preferences for children of either sex obtain. However, being regarded as an exclusively animal characteristic, multiple births are loathed; not only a woman who bears twins but also her relatives feel great shame. Only two sets of twins are now alive in Kabira, two men over sixty years of age and a boy and girl aged thirteen. In contrast with the view prevailing in at least some parts of Okinawa, the first-born twin is considered the older. Triplets are entirely unknown. Though at an earlier time not an uncommon practice, infanticide is no longer resorted to.

If she becomes an average mother, a Kabiran woman can expect to bear five or six children. Normally she gives birth to her first infant when about twenty years old. Her pregnancy does not curtail her usual activities beyond leading her to avoid trips to the mountains for firewood where she might fall and miscarry. Premature births, by Kabira definition, are rare, only one being recorded in the memory of the group; when they occur, the infant is kept in a dark, warm place for three months. Having taken the precaution to bind her abdomen securely in the fourth or fifth month, the woman continues to do her household tasks and to toil in the fields as strenuously as ever until the moment when her labor pangs begin. While pregnant, she must, however, strictly observe many minor food and activity taboos, particularly during the last month of her term. She must not: (1) step across the rope which ties a bull lest her pregnancy be extended to the term of that animal; (2) drink from a cracked cup lest her baby be born with a harelip; (3) attend funerals and eat foods which have been prepared as offerings to the deceased; (4) feed the pigs, for they would contract morning sickness and so fail to eat and grow properly; (5) make a tie for a bag lest the birth be prolonged. Her husband must likewise be particularly circumspect in his behavior: for instance, he is forbidden to close a paddy field drainage gate and to kill an animal. An occasional husband suffers from morning sickness during his wife's

pregnancy, in which case the severity of her infirmity is materially lessened.

Only once within the memory of Kabirans has the village boasted a midwife specialist: she came soon after the last war and remained until 1952, her departure leaving the community again without an expert. There are no women in the village who assume the role of midwife nor does there appear ever to have been such a group. Now, as in the past, a woman delivers herself with no more than incidental aid from her female kin.

No preparations are made for the delivery beyond the fashioning of clothes for the infant and the filling of a small pillow, for the infant's head, with millet or rice husks. With the onset of labor, the woman returns from the fields to the dwelling where she has been living, i.e., to the house she is occupying with her husband if she is already formally married but to her parents' home if she has not yet passed through the marriage ceremony. Still attired in her work clothing, she squats in a room corner where the thick *tatami* mat has been removed and the bamboo-pole flooring covered with old clothes or rice straw. This is the time when she, like all Kabiran women, shows deep concern about the position of the infant *in utero*, even though no instances of breech birth are remembered. Should the labor pains become severe, she either pulls on a rice-straw rope suspended from the house beams or simply bears down with determined force in her squatting position. When the labor is advanced and the birth delayed, her husband may be summoned to sit behind her, brace her shoulders with his hands, and push against her buttocks with his feet. The normal duration of labor is about six hours for a primipara and two to four hours for a multipara. There is a belief, however, that, whatever the time of the onset of labor, the child will not be born until the turn of the tide.

When the infant is born, the umbilical cord is tied with hemp thread and cut with scissors, and the placenta is delivered, all operations being carried out by the woman alone if she has delivered herself. While the birth is in progress, the husband fashions a rice-straw rope with recurrent clusters of seven, five, and three pendent straws. Now that the child is delivered, he proceeds at once to suspend this rope around the room from the ceiling, where it remains for ten days as a protection for the mother and infant against evil spirits and a warning to any pregnant woman who otherwise might inadvertently enter the room and thereby bring upon herself a difficult labor. He then buries the placenta, wrapped in a banana or taro leaf, behind the house, placing a stone on the earth above it to prevent rats and dogs from uncovering it. The infant is placed without delay in the temporary care of a female relative—its paternal or maternal grandmother or a maternal aunt—who immediately bathes it in hot water.

Once the delivery is over, the mother removes her old, soiled clothing and dons a kimono, though she bathes neither now nor at any time within the next ten days. During this entire period, she lies with her infant upon a thin straw-mat in another part of the same room, remaining completely inactive except for nursing the infant. However, the child is bathed daily by a female relative. When the navel cord falls free, it is carefully put away. On the second or third day following birth, the infant receives without ceremony a Japanese given name, a practice of comparatively recent origin. Upon the termination of this ten-day period, the amulet rope is removed from about the room and in a minor ceremony the child is given its Kabiran name, customarily that of the paternal or maternal grandparent of the same sex. Thereupon it is carried through the village to the homes of relatives to be proudly displayed and admired. If it is a first-born, it has its mother for its slave for many months. But if it has an older sibling, its general care is made the responsibility of its brother or sister after about a month and, as time passes, it finds itself with this sibling to an ever-increasing degree.

Nevertheless, the infant is literally a plaything for the entire family, young and old. It is overwhelmed with constant attention; it is incessantly suckled, sung to, fondled, and admired. If necessary, the entire household joins efforts to pacify it when it wails. When the mother is unavailable, any adult female relative, even a grandmother, gives the child her breast to silence it. As long as it remains the youngest member of the family and still within the age of babyhood, it receives this lavish attention. Generally it is nursed for a least two years and then intermittently until it is four or even older, if the mother does not again become pregnant. At one year, however, it begins to eat rice, sweet potatoes, fish, and vegetables and is frequently given a bit of pork or octopus to chew. Very little conscious effort is made in the direction of toilet training.

CHILDHOOD

Usually two or three years separate births. Upon the arrival of an infant sibling, the child enters a difficult period. A slight effort is often made to prepare a child for the abrupt change he (or she) is to experience in his pleasant pattern of life. If he is old enough, for instance, he may be promised the fun of carrying the infant on his back; because all children look upon this as a delightful and satisfying activity, he may find some solace in such a promise. Nevertheless, in general, his is temporarily an unhappy lot. To be sure, his physical wants are still carefully administered to, but he loses the remnants of his mother's devoted attention. To this moment she has revealed her affection in every act, and, to some extent, has continued to nurse him and even carry him on her back while pregnant. Now, however, he is placed entirely in the care of an older sibling, a cousin, or perhaps a neighbor child. He finds himself rejected not only by his mother but also, in some measure, by his whole household which promptly transfers its affection and attention to the infant. Being for the first time physically and psychologically separated from his mother and no longer the center of attraction for his kin, he feels insecure for the first time in his life. Now he is reprimanded when, unhappy and emotionally tense, he cries or demands attention. If he resorts to tantrums, he is either ignored or scolded sharply and is left to cry his anger and frustration away. When he runs after his mother as she goes about her work with the new baby on her back, begging her in howls of anguish to carry him as well, he may be taken by the hand none too gently, but more frequently he is upbraided or even taunted as she walks on, leaving him to continue his ululation and so to be further berated by his grandparents. This difficult period of adjustment lasts some months. As the child discovers that attention is no longer his at his bidding and resigns himself to the new situation, he moves away from his parents psychologically, transfers his chief attachment to his older siblings, begins to associate with children of his age group, often relatives, and so finally finds a satisfying niche for himself in their company.

The behavior of the developing child is canalized according to the social norms through prompt and warm praise, scoldings, coaxing, cajolery, uncomplimentary comparisons with other children of equivalent status, occasional threats of harm from the policeman, Itoman people, or demons, and even a sharp slap on the buttocks under rare conditions. Punishment of the latter type is administered by the mother. At this age a child receives its first conscious training: for example, in the evening after the meal a girl is encouraged to learn the traditional dances while her father or grandfather plays his samisen and sings the accompanying songs.

Duties come early to children, particularly to girls. True, from the age of seven when they enter school until their final year of Middle School nine years later, much of children's time is occupied by school activities. Reading and writing in Japanese, mathematics, Japanese literature, "social guidance," and physical education are the basic subjects of their educational program. But upon returning from school for the day, they find many household tasks to keep them busy. A seven-year-old girl washes her own laundry. She bathes and otherwise cares for a younger sibling with great tenderness, carrying it about hour after hour, strapped securely to her back. Though she plays freely even while thus encumbered, she is always conscious that her chief responsibility is to keep the youngster contented and comfortable. By the time she is nine she makes some, and repairs all, of her own clothing. At ten a girl is expected not only to minister to her younger siblings but also to wash her own garments and theirs too in the distant river, start the kitchen fires, bring home heavy pails of sweet drinking water from the hillside wells on the edge of the village, quern and pound the rice to remove the husks and steam it for the family's meal, help in the fields, wash and mash the sweet potatoes for the animals' food, and even carry her own small basket of these tubers in from the field. Alone or with companions of her sex and age group, she journeys to the mountains to gather firewood for the the household hearths. These duties she accepts gracefully and performs with developing skill. She is praised by adults for tasks willingly and well executed: inasmuch as praise means a great deal to the ten-year-old, for all that it is accepted quietly, it is a most effective incentive to proper behavior. However, she does her work not only for commendation but also to display concretely her affection for her family and to identify herself as a cooperating member of the household. When she shirks her tasks, she is scolded or ridiculed; she is already too old for physical punishment. Gradually, as she adds

years to her life, her responsibilities increase until, by the time her education is completed, she can perform the broad range of duties which fall to the lot of the adult Kabiran woman.

Boys, in contrast, do not assume responsibility so early in life. A lad of eight, without sisters to undertake the task, accepts full charge of a younger sibling and cares for it sympathetically without embarrassment or irritation. But, unless the household includes very few children, he normally escapes the many heavy responsibilities of his sister. Reaching the age of twelve, he is expected to gather grass for the horse and bull, and to cut food for the goats. Moreover, he may occasionally ride the horse out to the field or lead the bull to where his father is working. By the time he is fifteen, however, he gives substantial aid in the agricultural pursuits of the household, especially at harvest season. And from this period of his life he comes to follow more and more the work pattern of his male elders.

Clearly childhood is not pre-eminently a play period. Children do enjoy a few games, including varieties of hopscotch and jackstraws, even though possessing virtually no toys beyond captive birds, dragonflies, turtles, and the like. They have long been acquainted with simple string tricks, although string figures have but recently appeared in Kabira. When not assisting about the house, two or three youngsters of the same sex and age—close friends and constant companions, for Kabira children form strong attachments and firm work-play groups—stroll quietly about through the village, with their sleeping charges upon their backs if they be girls, hunting bugs and cicadas, playing with plants and flowers, watching adults at their varied activities, and so on.

ADOLESCENCE

Neither sex seems to suffer any obvious psychological maladjustment during adolescence, although girls then begin to speculate upon whom they will marry and even may be bantered somewhat by their elders about their marriage prospects.

At sixteen, Kabiran youths complete their schooling, except for the very few, mostly boys, who receive higher education in Shika. Thereafter until they marry they devote their time to the varied pursuits of their household. Upon their completion of school, all young men and women join the Youth Association and thoroughly enjoy the opportunities which its activities afford to continue their school friendships and their contact with their own age group. The association meets approximately biweekly in the late evening when the work of the day has been accomplished. Following the discussion of the issue which occasioned the gathering, members indulge in a period of talking, jesting, singing, and simple relaxation. This group likewise plays an important role in village affairs. Its members present dances at ceremonies, assist in the entertainment of prominent visitors to the village, and lend a strong hand in other community activities when their aid is required. Both male and female members occasionally work for other villagers by the day and assign their earnings to the organization treasury. On the whole, however, youths regard the association as a social club. Men continue their membership until twenty-five years of age while girls remain members until they marry or bear a child.

MARRIAGE AND ADULTHOOD

Marriage is invariably monogamous. Concubinage, though permissible, is rarely practiced; a concubine lives apart from the wife and occupies a lower status. The only formal barriers to marriage are those of kinship; this restriction extends collaterally beyond the nuclear family through all four classes of first cousins, but does not include second cousins. Providing this restriction does not apply, unions are allowed not only between members of the same *yaa*—and hence between individuals with the same family name—but also within the temple congregations and all other social groups. It is thought best, nevertheless, to marry well away from immediate kin, both patrilineal and matrilineal. Still, virtually all marriages are between co-villagers, a natural result of the isolation of Kabira. Thus the community comprises, functionally speaking, an essentially endogamous unit. Residence is patrilocal from the point of view of the husband if he is an eldest son; otherwise it is customarily neolocal, though still within the community. The single exception to this usual pattern occurs when a husband is adopted for a daughter who is an only child, the residence in this case being patrilocal from the standpoint of the bride.

Every normal individual is expected to marry. The minimum marriageable age is about seventeen for girls and nineteen for men; unions are usually formed soon after these ages are attained. In general, youths of both sexes are allowed to

select their mates. Naturally, one who dawdles over choosing a spouse until well beyond the customary marriage age is urged by his family to come to a decision. Moreover, occasionally one is encouraged by one's parents to marry a person of their choice. But neither of these procedures is common. Courtship is a private matter, carried on outside the home and generally, it would seem, beyond the village limits. When a young man decides upon a girl—or when a young couple come to a mutual understanding—he confides his choice to his parents, who then inform the girl's parents of the desire of their son. If both the girl and her parents approve of the match, the union is decided upon. A period of trial marriage follows, the wedding ceremony taking place only when both families have accumulated the necessary property. During this interim the girl continues to live with and work for her household, her father setting aside a room in the dwelling as a meeting place for the couple. The couple usually have one child, and frequently more, before sufficient wealth has been acquired for the ceremony. No stigma is attached to a child born during this period, even if the couple later decides not to make the union permanent with the marriage rite. In this interval before the wedding, separation is frequent and is unaccompanied by formality.

When both families can at last afford the wedding, the man's parents consult the village diviner to determine a lucky day for the rite and they at once inform the bride of the date. The ceremony is normally held in the eighth lunar month. Its initial component consists of an elaborate feast at the bride's home, at which she, her relatives and friends, and a male and female marriage counselor are present. This latter pair, the historical equivalent of the usual Oriental "go-between," have in Kabira no function before the wedding; rather, it is their duty to act as advisers after the marriage with the aim of keeping the couple together should serious difficulties or misunderstandings arise. Today these counselors are a husband and wife who have many children and are considered happily married. After this feast the bride bids farewell to her family and ancestors and, accompanied by her counselors and her female attendants who bear her clothing and simple dowry, walks to the home of the groom. At the gate of the groom's compound she is met by his mother, is escorted into the dwelling, and is introduced to her husband's relatives, whom, being co-villagers, she already knows well, and finally to his ancestors. A feast identical with that celebrated at the bride's home is now held at the groom's for his family, relatives, and friends. As its conclusion, the bride drinks sake ceremonially with the groom and his parents. After the wedding ceremony the bride remains with her husband. If he is the eldest son, they take up permanent residence with his parents; if not, they may live with his parents temporarily but only until they are able to build a small dwelling where they can start a new household alone.

Permanent separation rarely occurs after the marriage ceremany has been celebrated. It may be initiated, however, by either party for any one of several reasons (e.g., extreme laziness on the part of the other) but barrenness is never the cause of family dissolution, such a situation being easily remedied by the adoption of a second or subsequent son, or even of a daughter, of a related family. Separation following the formal rite is more common when a girl marries an eldest son, for her life is particularly unhappy. To her lot falls the bulk of the work of the large compound, the other women of the household placing in her hands many of the tasks which they had performed until that time. Regardless of how desperately she tries to please, her conduct is the target for constant criticism from her mother-in-law and unmarried sisters-in-law. She must continue in this unenviable status for many months; indeed, she is referred to as "the bride" until the death of her husband's mother, only then rising to pre-eminent position as mistress of the compound. But sometimes a bride finds intolerable this combination of withering criticism and hard work and, swallowing her mortification, leaves her first-son husband after a year or so. If she has borne children, she takes them with her to the home of her parents. Her husband and other kinsmen then endeavor to bring about a reconciliation and to persuade her to return. As an eldest son, her spouse must remain with his parents: he cannot even entertain the idea of establishing a household apart from his family of orientation, where conditions would be more congenial to his wife. If all efforts toward a reunion of the pair are unavailing and the separation is permanent, the disposition of the children becomes a problem. Usually they are hers to rear if she does not later secure another spouse. Should she remarry and her own family have no children to carry on their line, she must

leave the offspring with her family. However, even this regulation is tempered under certain circumstances. If, for example, having formed a new alliance, she should bear no children, she has the right to recover a son by her first marriage to serve as heir for her second husband. Moreover, should her former husband, establishing a new family of procreation, have no offspring, he may take back to his compound a son by his first wife to perpetuate his joint family. But if, after having taken such a son with intent to establish him as his heir, he should father a son by his second wife, this latter son automatically becomes his primary inheritor. In this event, the first son receives a special name, is granted some property, and, upon attaining his adulthood, leaves his father's compound in favor of his half brother.

Contrasting with this situation in a first-son marriage is that which obtains in the case where the husband is a second or subsequent son. Because it is necessary in this instance for the husband to found with his wife a new household apart from his parent's compound, friction between his wife and her female in-laws is minimal and permanent separation is very rare. In any instance a second marriage ceremony is never performed for either sex. When one or both members of a union have been previously married, the pair simply forms a co-resident unit with the structure and all the functions of a family but without the formality of the marriage rite. Such a union is accepted as wholly proper.

A couple devotes its primary attention to rearing its children, tilling its fields, improving as opportunity arises the comfort and substantiality of its compound, and augmenting its holdings of paddy plots, dry fields, and animals. The resources with which a pair starts its life together depend far more upon the position of the husband in his family of orientation than upon any other factor. An eldest son and his wife, continuing the patrilineal family, have at their disposal the superior fields and rice terraces of the joint family, its compound, and most of its other possessions. With the acquisition of these, however, they also assume the burdens of the family, in particular those of holding the ancestral ceremonies and of discharging certain responsibilities toward the husband's younger siblings. Lesser sons, on the other hand, have very few possessions when they marry and their individual allotment of paddy and dry fields embraces the poorest plots of the joint family as well as the smallest and most distant from the village. In general, until they increase their property through years of diligence, they possess a simple home, little agricultural equipment, meager land holdings, and no large animals. In return, save for a duty to help with the harvest of a major crop, with ceremonial preparations, and with any construction which may be undertaken at the parent's home, they are free of responsibility toward their parental compound. For this reason, as well as for the freedom of action they enjoy in a household by themselves, many Kabirans consider younger sons more fortunate than their eldest brother, and most girls honestly prefer to seek their spouses among the younger son group.

OLD AGE

By the time their children attain adulthood, most couples have acquired a substantial home and enough dry and wet fields to enable them to pass on a respectable inheritance to their first-born son and the necessary minimum for survival to their younger sons when they wed. With his forth-ninth birthday a Kabiran male reaches the traditional age of retirement. About this time a man generally transfers to his eldest son his heavy duties and his obligations toward the joint family. In his new-found leisure he knots fish nets (fig. 7), weaves basketry (fig. 8), and enjoys his grandchildren. Nevertheless, if the number of his male descendents is small or if few remain within the compound, he continues to help with the harvest and more important agricultural activities. For a wife, on the other hand, the change at this age is less marked: she carries on with much of her work. She still tends the pigs, sweeps the yard clean, cooks the meals, and often digs sweet potatoes daily. If she has many small grandchildren, she may assume their care while their several mothers perform their household tasks and their older siblings are in school. But the greater the number of children and grandchildren, the lighter are the labors of an aging couple. Old age, in sum, does not actually mean complete retirement for either sex. It does bring with it, however, the respect and esteem of the younger family members and, in fact, of all younger co-villagers.

DEATH

Death is customarily attributed to natural causes, not to a curse or evil design. Nevertheless, should two deaths occur within a short time in a single family, some mysterious, malevolent in-

fluence is regarded as the possible cause. In case such be true, a chicken is killed and buried with the second body to appease the responsible deity. The fowl actually counts as the third death in the family which the ill-disposed spirit would otherwise cause. When native medicines fail, death is felt to be inevitable; both the patient and his relatives become resigned to it. Death, then, is not feared; like birth and the other truly important events of life, it is regarded simply as one of the natural phases of existence.

A person is pronounced dead by his father or a near male kinsman, the decision being reached by little more than an attempt to find the pulse. As soon as all life has faded, female relatives bathe the body, cut the fingernails and toenails, trim the hair, and wrap the clippings in a paper to be buried with the body. As their final duty, they dress the corpse in a fine kimono. No wake is held and the burial is never delayed beyond the day of death or the following morning at the latest. A carpenter is called in at once to fashion a coffin. The old horoscopist of the village having been consulted as to the precise hour most auspicious for the burial, a black-bordered announcement of the funeral is posted on each of the village bulletin boards. Before the hour of the funeral, a member of each household of the community is expected to call at the home of the deceased with a small money gift to help defray the entombment expenses. When the coffin has been finished, the body is placed within it on its back in a knee-chest position. A list of the money contributors, previously prepared, is placed on the chest of the corpse. Such objects as the teapot and cup, rice bowl, chopsticks, dishes, and pipe of the deceased are set on a tray close by; they are to be carried to the tomb with the body and left atop the coffin. While these activities are taking place, female relatives gather at the home to cook, though no actual feasting occurs, and to help with the household preparations. Village men who are skilled at the task contribute their services by cutting and assembling the paper flowers, birds, and lanterns required in the funeral rite.

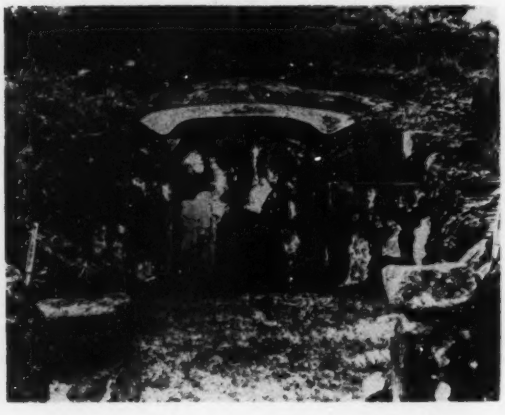


FIG. 25. Tomb of common turtle-back type set into sidehill.

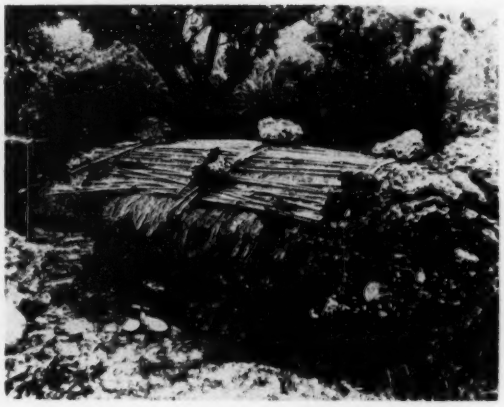


FIG. 26. A temporary adult burial of mud, coral stone, grass, and bamboo, placed within the extending arms of a turtle-back tomb. Such a structure is required when one adult within the sublineage dies soon after another. Since a body cannot be removed from the central area of the turtle-back tomb before the fifth year after death and since this area is too small to accommodate a second body, a second death within this span of time requires a temporary shelter of this type.

As these preparations are under way in the compound, male relatives of the bereaved family cut the brush and grass along the path the funeral cortege will soon follow, and they prepare the tomb for the interment. Most tombs now being of the elaborate "turtle-back" type characteristic of southern Okinawa (fig. 25) rather than of the traditional square variety, the men clean the tomb yard, remove the stone-slab door, and bring a supply of fresh mud to reseal the slab in place after the burial. Other young men bring in from its shelter on the western edge of the settlement the heavy communally owned palanquin-hearse.

When all is in readiness and the favorable hour arrives, the relatives, weeping quietly, listen as the Buddhist priest, summoned from Shika, chants the traditional rite. If the family cannot afford

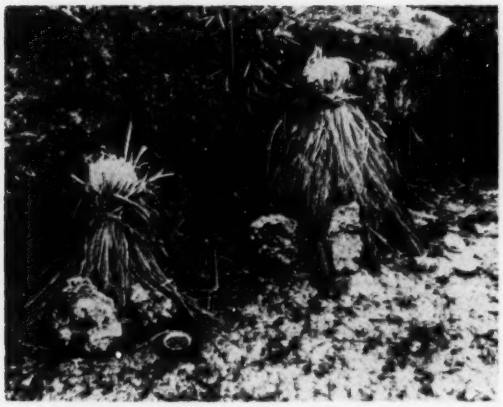


FIG. 27. Two child burials within walls of tomb area. Beneath the straw cover is a small coffin holding the body or a pottery jar containing the bones. The cups and bottles, now in disarray, were used in making offerings to the deceased.

the priest's services, this portion of the ritual is dispensed with. Then they individually approach the coffin and bow farewell to the deceased. This rite completed, the coffin is slipped into the palanquin and is carried by male kinsmen to the tomb. The family and friends follow in a solemn procession without music and loud lamentation. Should a person lie ill in a dwelling along the route of the cortege, a rice-straw amulet is placed at his compound gate to prevent the deceased's spirit from taking his soul with him and so causing his death.

At the tomb the coffin is set for a brief moment in the open yard within the masonry wings while a final, short prayer is intoned by the priest. It is then slipped into the crypt and the tray of utensils is placed on top of it. Male kinsmen seal the tomb; each relative, lighting incense, prays briefly; and all return to the village. Only members of the immediate family return to the dwelling of the deceased.

Special circumstances give rise to variant procedures within this usual pattern (fig. 26). To illustrate, a child is not placed in the sublineage vault; instead, its tiny coffin is set in a small depression in the tomb yard and is covered with a conical, rice-straw roof (fig. 27). Again, a person who succumbs to tuberculosis, an ailment intensely feared, is buried at once in the ground far from the family tomb with only the immediate family in attendance, for the tomb is closed to all who die of this abhorred disease. What is more, a grave of this kind is henceforth avoided by all but the closest relatives.

Immediately upon its return from the interment at the tomb, the family gathers the personal possessions of the deceased and arranges them before the *butsudan* (fig. 13), where they remain for forty-nine days. Upon the expiration of this period they may be distributed among the surviving family members. The grave responsibility of holding the important memorial services falls to the surviving members of the joint family. Each day during the week following the demise they visit the tomb in the morning, carrying tea and esteemed foods to the deceased. On the forty-ninth day they go again with tea and food, and upon their return home hold a ceremony for the dead person before the family *butsudan*. The memorial name given the deceased by the Buddhist priest is now written upon a small wooden tablet and is added to the plaques of the other ancestors upon the *butsudan*. Thereafter the commemorative rituals are held as prescribed, especially in the first, third, twenty-fourth, and thirty-third years following the death.

On the third, fifth, seventh or ninth year after death the bones are removed from the coffin, washed with water by young female kin of the joint family, stacked in a large earthen jar, and returned to the crypt. Upon the conclusion of the thirty-third-year memorial service, the ancestor is presumed, rather vaguely, to ascend to heaven. Soon thereafter the bones are transferred from the jar to a large general bone-box in the rear of the crypt. This traditional treatment of the bones is now, however, undergoing change. More and more commonly Kabirans are cremating the bones when they remove them from the coffin, instead of washing them, and are placing the ashes in the jar within the tomb. Furthermore, the cremation is performed by male relatives rather than by the women of the family.

A LAND USE RECONNAISSANCE IN NEPAL BY AERO-FIELD TECHNIQUES AND PHOTOGRAPHY[1]

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NEPAL, in common with most of South Asia, is faced with an intense population pressure in relation to its arable area. Despite rugged topography and relatively unproductive soils, Nepal has an average population density of over 150 persons per square mile.[2] The density in relation to cultivated area is more than 1,300 per square mile. To aggravate the problem, the present population of eight and one-half million is increasing at an estimated rate of five per cent annually.

As population pressure mounts, it will be difficult to maintain even the low living standard without improvement in present land used to secure maximum productivity.

A land use inventory is basic to the solution of the complex agro-economic problems of the country. There is little trustworthy data concerning the proportion of Nepal's land utilized for crops, the amount of land devoted to grazing and forests or the exact extent of the waste and barren areas. Were this essential information collected and mapped, the planning of agricultural development in Nepal would be greatly facilitated.

The distribution of land in Nepal among agricultural, grazing and forestry, and waste and barren areas and the factors which have led to this pattern are of concern to geographers. A land use inventory of Nepal such as that presented here may be, therefore, a worth-while addition to the limited source material.[3]

THE PHYSICAL BASIS OF LAND USE

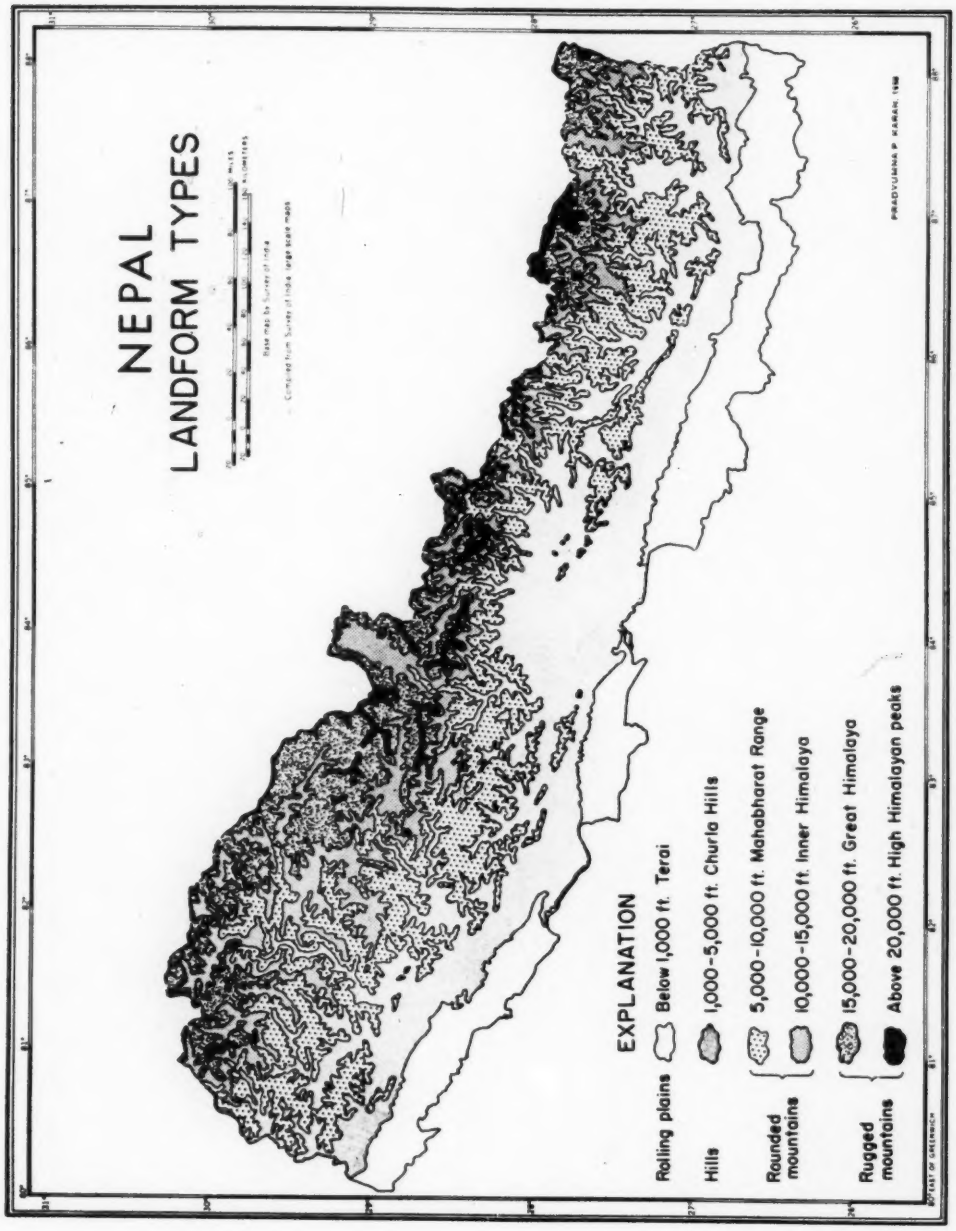
The physical factors like topography and climate set broad limits upon the use of land and it is necessary to outline briefly the essentials of relief and climatic conditions in Nepal.

The Kingdom of Nepal lies along the slopes of of the Himalaya between Communist-occupied Tibet and India, and extends from the sub-Himalayan terai plains of the south to the Great Himalaya in the north (map 1). It is undoubtedly one of the most mountainous countries in the world drained by a series of rivers which flow across the Himalaya in deep gorges (map 2). Politically the country is divided into thirty-eight districts (map 3) which are grouped into nine geographic regions (map 4). But from the topographic standpoint there are four major physical divisions: (1) the sub-Himalayan terai plains bordering India, (2) the foothills, (3) the rounded mountains of the Mahabharat Range and the Inner Himalaya, and (4) the rugged Great Himalaya above 15,000 feet (map 1).

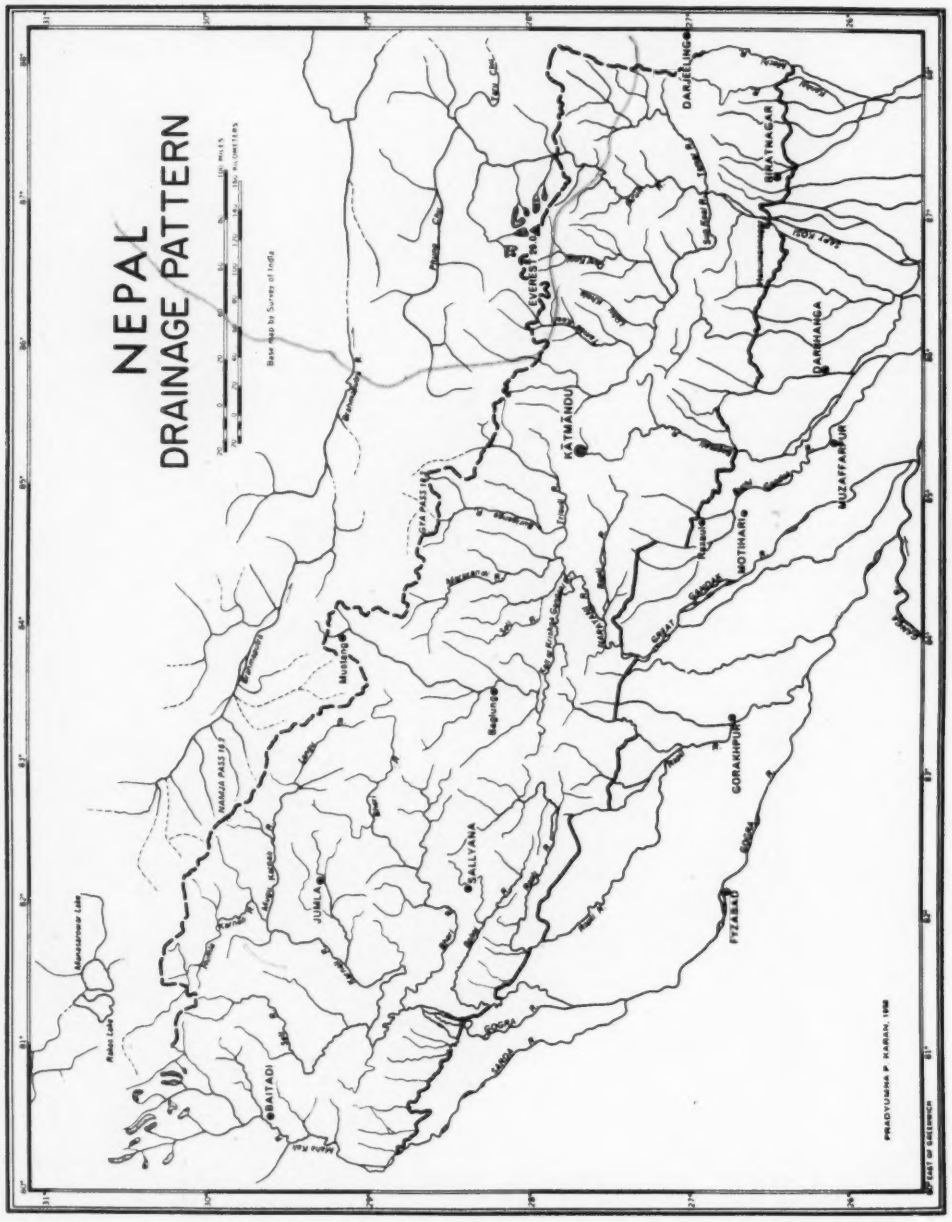
[1] This paper is based on field research in Nepal during 1957 supported by a grant from the American Philosophical Society. An earlier version of this paper was read at the annual meeting of the Association of American Geographers in Pittsburgh, April, 1959.

[2] All population figures in this paper are from Government of Nepal, Department of Statistics, *Interim report of the census of Nepal*, Katmandu, 1955, published in Nepali.

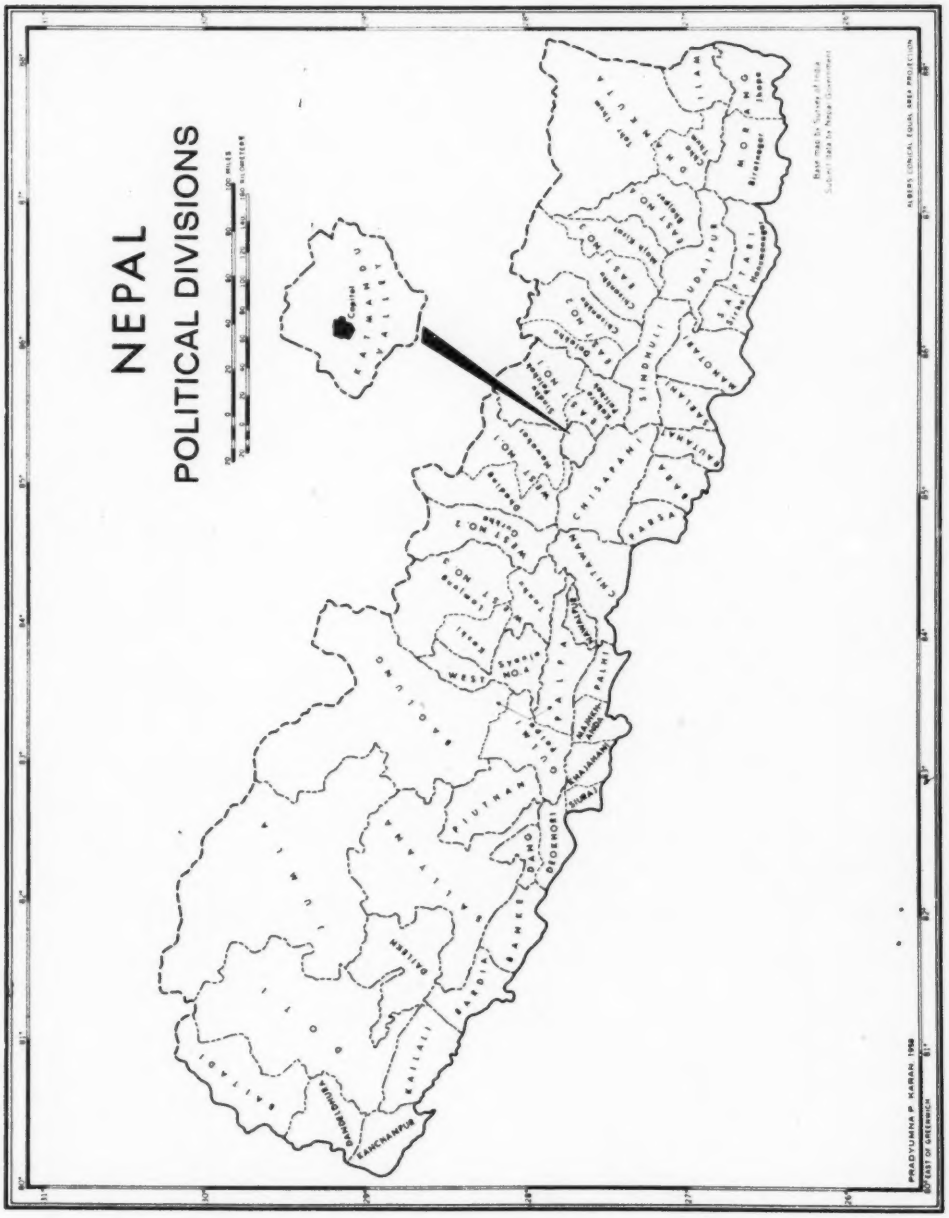
[3] One of the best bibliographies of published material on Nepal is by Margaret W. Fisher, *A selected bibliography of source materials for Nepal*, University of California, HRAF South Asia, 44 pages, Berkeley, no date, mimeographed. This includes all the important publications up to 1954. For a recent list of materials published by government agencies in Katmandu and writings on Nepal by Nepalese, see P. Prasad Karan, Aids to geographic research on Nepal: a review of recent publications, *The Professional Geographer* **9** (1): 17-18, Washington, D. C., 1957. Y. P. Pant has written several pamphlets on economic problems published by the Nepal Cultural Association, Katmandu, between 1956 and 1958. Perhaps the most useful is *Planning for prosperity in Nepal*, Katmandu, 1957, but even in this Pant is unduly optimistic of economic potentialities. More conducive to an understanding of Nepal are three books (mimeographed) published in 1958 by Human Relations Area Files, Inc., New Haven, Connecticut. These are: Ravi S. Sharma, John H. Cover and Nikki R. Keddie, *The economy of Nepal;* Stanley Maron, Leo E. Rose, and Juliane Heyman, *A survey of Nepal society;* and Leo E. Rose, *Nepal: government and politics.* None of these books give a connected account of the geography of the country, and there are no maps or illustrations. For those interested in agriculture, Chapters 1 and 2 in the volume by H. Kihara, editor, *Land and crops of Nepal Himalaya*, Kyoto, 1955, give an account of the land use in the area to the north-west of Katmandu. A general survey is by Pradyumna P. Karan and Alice Taylor, Nepal, *Focus* **7**: 10, New York, 1956. For a general geographic survey see Pradyumna P. Karan and W. M. Jenkins, *Nepal: a physical and cultural geography*, Lexington, University of Kentucky Press, 1960 (in press). It contains over one hundred maps and photographs.



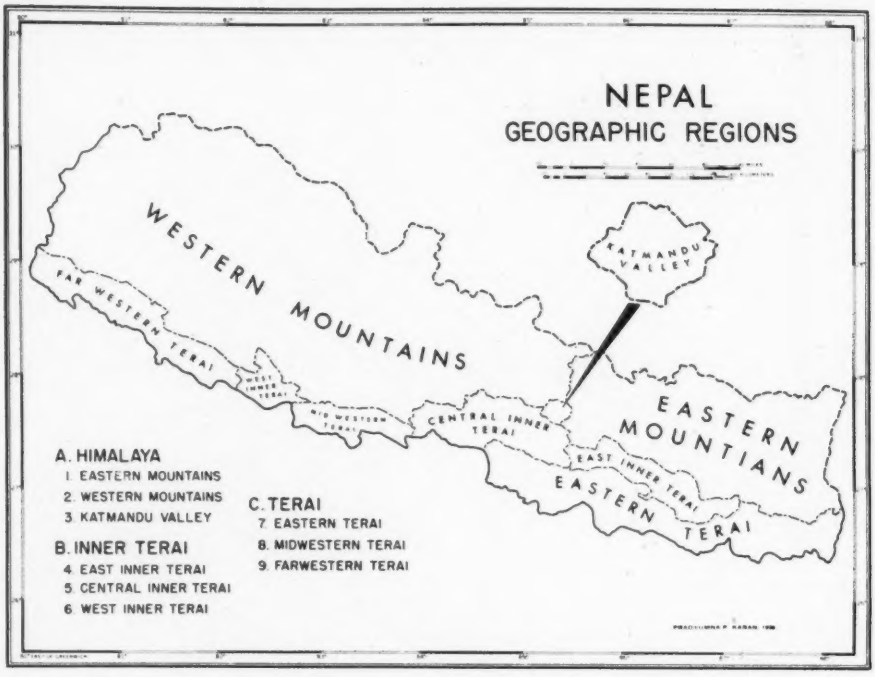
MAP 1. Landform types. Based on Survey of India 1 inch to 4 miles map sheets.



MAP 2. Drainage. Based on Survey of India 1 inch to 4 miles map sheets.



MAP 3. Political divisions. Based on data collected from official sources in Nepal.



MAP 4. Geographic regions. The regions are based on total physical and cultural geographic expression of landscape complex. Each region has a unique geographic personality which distinguishes it from the rest. Existing district boundaries, although arbitrary in some places, have been used in delimiting one region from the other. This facilitates the use of official statistics (collected district wise by governmental agencies) in further geographic investigation of the regions.

The terai plain forms the northernmost extension of the Gangetic plains of India. It varies in width from sixteen to twenty miles but narrows considerably in certain sections. This rolling plain consists mainly of alluvium which is gravelly in the north.

The foothills of the Nepal Himalaya rise steeply from the terai plains. They contain a succession of more or less broad longitudinal valleys which attain great prominence in certain sections.

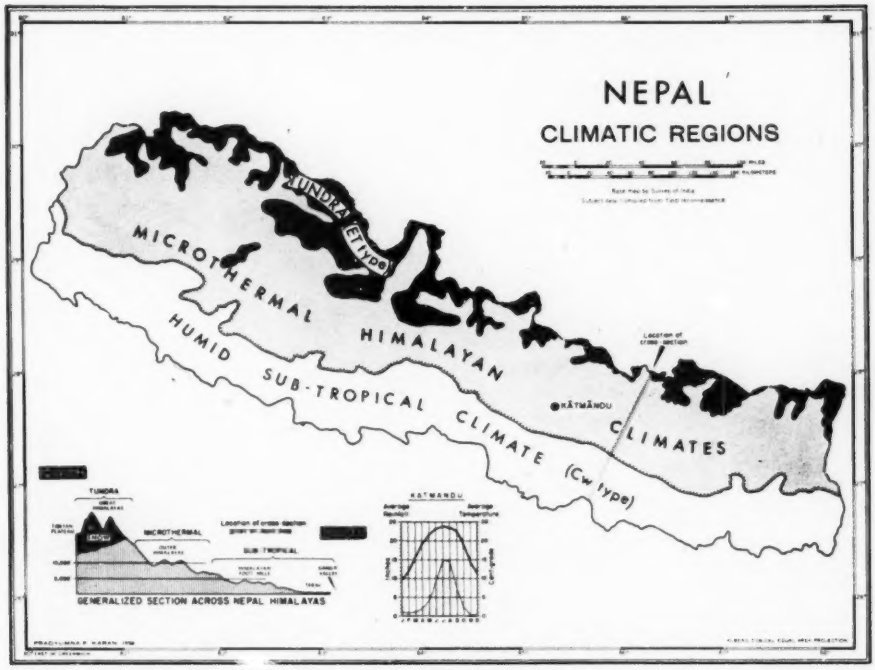
The Mahabharat Range and the associated mountains of the Inner Himalaya are about forty to fifty miles in width. This region encloses several fertile valleys, including Katmandu Valley—the heart of the country—and contains the bulk of Nepal's population. Most of these densely populated and intensively cultivated valleys are located at altitudes varying between 4,000 to 5,000 feet.

To the north of this zone are the more lofty and rugged mountain ranges of the Great Himalaya rising into peaks of perpetual snow. It is uninhabited except for small scattered settlements in the narrow, rough, and stony mountain valleys.

From the point of view of climate three regions can be distinguished (map 5). Along the southern border up to 5,000 feet the climate is humid sub-tropical. It is a warm and humid area with a rainfall of eighty inches in the east decreasing to about forty inches in the west. North of this the climate changes with elevation. The Mahabharat Range and the Inner Himalayan chains have undifferentiated microthermal climates. In general the winters range from moderately cold to severe in this zone and the summers are warm and rainy. Beyond the undifferentiated microthermal climates, above an elevation of 15,000 feet, the climate is truly alpine tundra.

THE PROBLEM OF LAND USE MAPPING

The general concept of land use mapping has been to make detail on-the-ground field surveys



MAP 5. Climatic regions based on vegetation. Generalized map based on field reconnaissance. Rainfall and temperature graph of Katmandu based on official data.

to plot information on the use of lands for agricultural or other purposes on large-scale maps or air photograph base.[4] The Land Utilization Survey of Great Britain, the Michigan Land Economic Survey, Rural Land Classification Program of Puerto Rico, and the land use surveys of the Tennessee Valley Authority are all examples of such land use mapping of extensive areas by geographers.[5] Land use can now be mapped quickly and accurately from the air photos wherever available.[6] However in many parts of Asia and other underdeveloped areas of the world aerial photographs are not available,[7] which results in excessively heavy demands both on the time and effort of the geographer in land use inventory. But in areas of exceedingly tortuous terrain, on-the-ground mapping of land use is an exceedingly difficult and tedious task for the geographer.

Realizing the need for some new kind of field tool and techniques for quick land use inventory of large underdeveloped areas of the world, this writer attempted to map land use patterns in Nepal with low-oblique photographs made by hand cameras from light airplane. The use of light airplane and hand camera in geographic re-

[4] Charles M. Davis, "Field Techniques" in Preston E. James and Clarence Jones (editors), *American geography: inventory and prospect*, 507-516, Syracuse University Press, 1954.

[5] See L. D. Stamp, The land utilization survey of Britain, *Geographical Journal* **78**: 40-53, London, 1931; Z. C. Foster, *The use of aerial photographs in the Michigan Land Economic Survey*, American Soil Survey Association, *Bulletin* **13**: 86-88, 1932; Northwestern University, Department of Geography, *The rural land classification program of Puerto Rico*, Evanston, Ill., 1952; G. Donald Hudson, *The rural land classification program, Tennessee Valley Authority*, Washington, D. C., 1935; G. D. Hudson, The unit area method of land classification, *Annals, Assn. of Amer. Geogr.* **26**: 99-112, Lancaster, Pa., 1936; G. D. Hudson, Methods employed by geographers in regional surveys, *Economic Geography* **12**: 98-104, Worcester, Mass., 1936.

[6] G. M. Howe, A note on the application of air photography to the agricultural geography of north-west Cardiganshire, *Geography* **36**: 15-20, Sheffield, England, 1951.

[7] See map of the world showing air photo coverage in 1957 in Kirk H. Stone, World Air Photo Coverage, *The Professional Geographer* **11** (3): 2-6, Washington, D. C., 1959.

search is by no means new.[8] In 1947 a land use study of the Santa Maria Valley in Southern California was made using light airplane and 35-millimeter camera as inexpensive and versatile field tool combination.[9] This aero-field technique and photography was successfully tested in a land use inventory of Nepal in 1957. Its full worth was specially demonstrated in mountainous Nepal, which is exceedingly difficult of access owing to heavy vegetation cover, rugged terrain, and almost complete lack of roads and trails. The small 35-millimeter camera and the light airplane have proven themselves remarkably versatile, effective, and dependable in land use inventory in the Himalaya. The data collection (photographs) for mapping land use pattern was accomplished in a fraction of the time otherwise needed for collecting the same information by tedious on-the-ground "walks."

By using this aero-field technique the geographer is free from the usual physical impediment of the terrain over which he must move to map land use, as well as from the entanglement of the vegetation itself. Ridges, gorges, rivers, or dense forest can be crossed at will without undue deviation or delay. Land use pattern over a large area in all its complexity can be viewed and photographed from air in its complete total pattern from a high altitude (e.g., 2,000 feet from ground level) or viewed and photographed for detail close-ups from a low altitude (200 feet or so). Since the geographer is concerned with areal association of phenomenon and their spatial patterns [10] only the air view reveals best the manifold features of the landscape in their complex totality to permit study and inventory of areal distributions and pattern associations. To the trained geographer the air photograph is "a nearly complete and definitive full-detail miniature-likeness record of a given landscape complex." [11] In the air view the land use complex is revealed in precise panoramic arrangement without ridges or hills blotting out the view—and may thus be seen and studied as "total composite regions" [12] with full geographic expression of landscape complex.

LAND USE MAPPING BY PLANE AND CAMERA

From the light airplane, at low altitude, the geographer can thus observe, associate, and even make aerial sketch-maps of various types of land use, while at the same time he can record land use on photographic film (either black and white or color or both). In contrast to the standard

FIG. 1. This black and white print made from a 35 mm. Kodachrome slide taken in eastern terai of Nepal from light airplane with camera held in the hand. Note the large agglomerated village surrounded by cultivated fields (some of them flooded by monsoon rains). The 35 mm. color slides were projected on a screen to transfer the land use on map. Photographic Data: Altitude: 800 feet above mean ground level; Weather: clear sky; Direction: N 30 E; Location: eastern terai; Date: June, 1957. Argus camera 1/200 at f 4.

aerial photographs, which at very best are months or even years old, these personally made photographs provide up to date data on land use pattern. In addition, these personalized air photographs have the great advantage in permitting complete control over such elements as the subject composition, scale and area covered, detail and generalization and the angle of view by the geographer. The field geographer can use these

[8] The procedures and techniques concerning the use of the light airplane and 35 millimeter camera for geographic research are given by Clifford H. MacFadden, Some preliminary notes on the use of the light airplane and 35 mm. camera in geographic field research, *Annals, Assn. of Amer. Geogr.* **39**: 188–200, Washington, D. C., 1949.

[9] Clifford H. MacFadden, *op. cit.*, 188.

[10] Preston E. James (editor), *New viewpoints in geography*, 10, Washington, D. C., National Council for Social Studies, 1959.

[11] C. H. MacFadden, The uses of aerial photographs in geographic research, *Photogrammetric Engineering* **18**: 732, 1952.

[12] For an explanation of the concept of the region in geography see Richard Hartshorne, *Perspective on the nature of geography*, 129–143, Chicago, Rand McNally and Company, 1959.

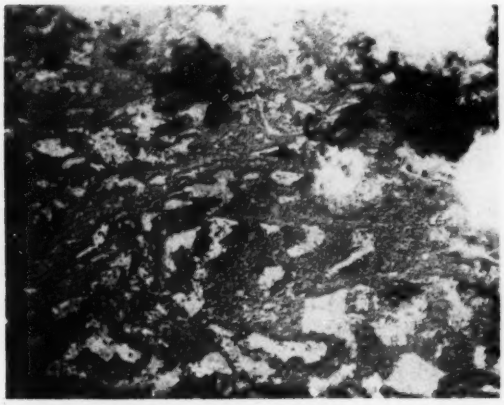


FIG. 2. This black and white print of 35 mm. color slide shows land use on the Churia Hills. Note the small patches of land cleared from woods for agriculture. Forests of mixed hard and soft woods indicate the humid sub-tropical climate. Note the shadow cast by clouds to the right. Photographic Data: Altitude: 1,000 feet above mean ground level; Weather: clear sky with some scattered low clouds; Direction: N 20 E; Location: Churia Hills in central Nepal; Date: July, 1957. Argus camera 1/200 at f 4.

elements in the way they suit best his research objective.

A variety of light airplanes, such as the Tiger Moth used in this study of Nepal, having slow cruising speed, stability, wide angle ground visibility and ease of maneuvering are excellent for this type of aerial research and photographic land use inventory. The field geographer can fly solo and observe, sketch-map or photograph at the same time. In the extensive land use inventory of Nepal a local pilot proved valuable as guide and landscape interpreter. Flying from Katmandu and points along the Indian border all of Nepal (except the barren and snow-capped Great Himalayan Region) were photographed between the months of May and August (see black and white prints of the 35 mm. color slides, figs. 1, 2 and 3). Eastern Nepal was photographed first in May and June because the monsoon rains set in early in the east, and western Nepal was covered later in July and August. Flights were made only on clear days in good sunny weather, and therefore several days were lost because of the rains and overcast sky. Given good weather and flying conditions in about three months a country of the size of Nepal can be photographed for land use mapping working on an average four to five hours daily. It should be noted that a good part of this time was used in general air reconnaissance to gain an over-all view of a particular region before actual low-oblique photography from the air. On the reconnaissance much time was spent in making notes, sketches, cross sections, and field diagrams (all keyed to map and photographs) as a prelude to photography. Later, these field notes from the air were very valuable in interpreting the land use features. Writing descriptive notes and field sketching require training and experience so that only significant observations are recorded to supplement the photographs.

The problem of localizing the photos taken from a small plane was very real in Nepal. Consequently the area to be photographed on a particular flight was carefully located on a large scale map at the time of exposure or was predetermined precisely on the map. Whenever feasible all obliques were exposed in a north direction for easier identification. Experience has shown that a careful location of the area on the map before exposure saves a great deal of time in identifying the photograph area when transferring land use features on the map. Frequently a river, trail, or large house or some other striking feature in

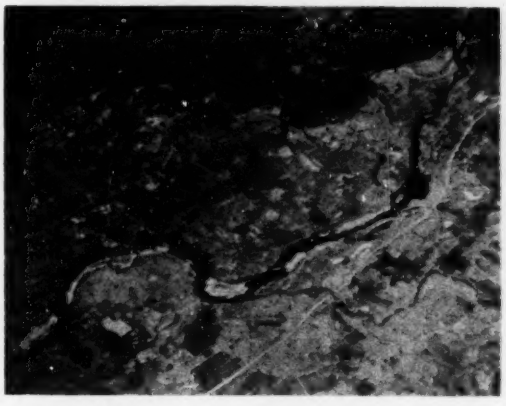
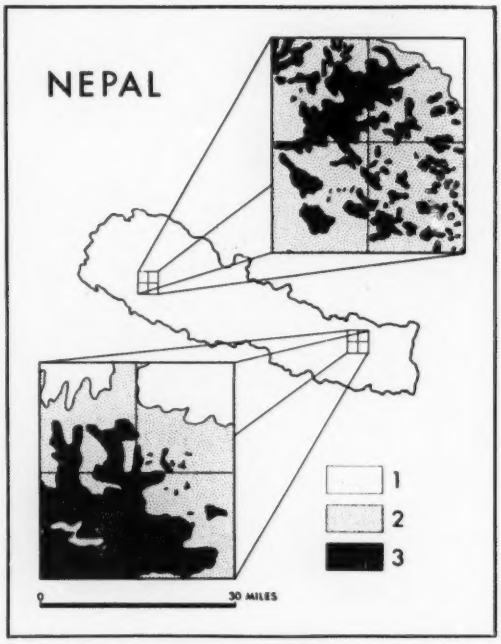


FIG. 3. This air photograph made from 35 mm. color slide illustrates the intensive agriculture typical of the mountain valleys in central Nepal. Contiguous cultivated fields (some of them flooded) cover most of this narrow east-west valley drained by the stream seen running across the photograph area. Woods begin to appear on the mountain slopes seen at the top of the picture. Photographic Data: Altitude: 2,000 feet above mean ground level; Weather: clear sky, light haze; Direction: N 50 E; Location: Palpa district; Date: July, 1957. Argus Camera 1/200 at f 4.

the landscape serves to localize the photograph on the map with a high percentage of reliability.

Camera equipment for aero-field work can be of any of the ordinary 35-millimeter types which are light in weight, simple to operate, and have low film cost. The inexpensive American-made Argus and the slightly more expensive German Practica yielded good results in Nepal. Although black and white film as well as the color Kodachrome can be used, the color photos comprise all of those taken in Nepal. Kodachrome color film, in spite of its slow speed, gives far superior results if exposed in bright sunlight, in recording land use than the simple black and white film on which land use features are often difficult to identify. The chief drawback of Kodachrome is that it can be used best only on clear sunny days, but the ease of identifying land use patterns on color film more than compensates for its demerit. The color film offers the geographer both the advantages of the details available from low altitudes and the shadings of true natural color in transfer mapping purposes. Film exposure was determined by the ordinary General Electric light meter. However, it was essential to use fast shutter speeds, preferably 1/200 to 1/500 of a second, to avoid distortion. A filter was used to correct the hazy conditions which are common in most areas.

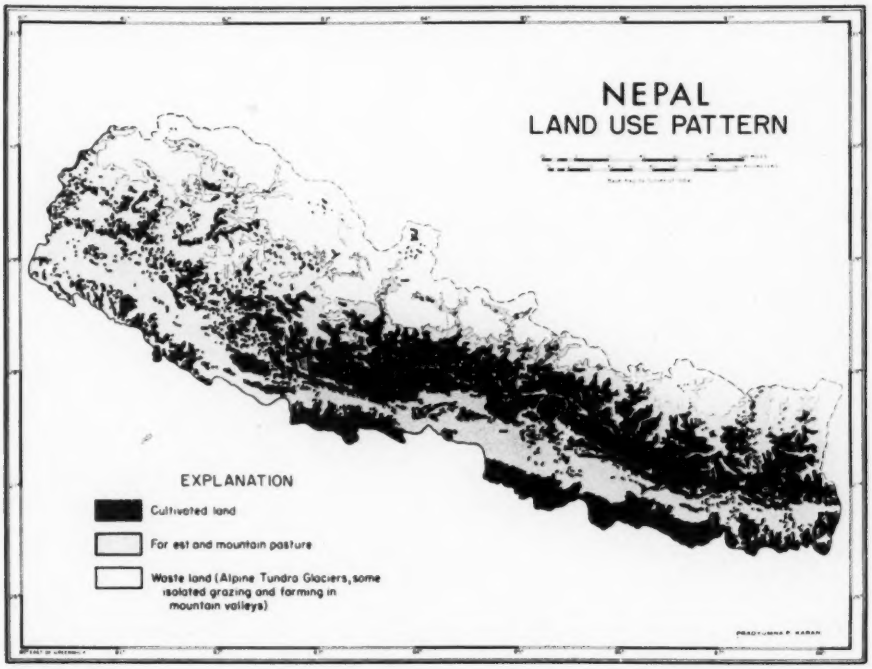
In the intensively cultivated areas of Nepal oblique photographs made from a height of approximately 800 to 1,000 feet above mean ground level (fig. 1) gave extensive ground cover in detail adequate for mapping the land use pattern.[13] Greater detail or greater generalization were obtained, depending upon the particular area of the country, by making photographs at varying altitudes of lesser or greater magnitude. Thus in the mountain areas uniformly covered with dense vegetation and having little complexity of land use, photographs taken from 3,000 feet, occasionally even higher, gave a large ground area coverage in good detail for mapping, in other areas, such as the valleys, close-ups were necessary to map the complexity of land use. Owing to limited financial support of this project, large areas of barren waste land in northern Nepal covered by alpine tundra and glaciers (fig. 4) were not photographed to save the cost of film.



MAP 6. Sketch illustrating the procedure used in compiling the land use map of Nepal. The entire country was divided into a number of rectangles as shown in the sketch. Land use was plotted in each of these rectangles from the 35-mm. color slides. The two insets show the land use in the area covered by the rectangles on a larger scale. Key to numbers: 1, wasteland (alpine tundra or glaciers); 2, forest and mountain pasture; 3, cultivated land.

FIG. 4. This photograph gives a view of the Great Himalayan region. It is wasteland covered by alpine tundra or glaciers. Most of this area was not photographed since the region is barren and wasteland from the point of view of land use.

[13] If a telephoto lens is used, then higher altitudes can be flown with equal or even better results.


NEPAL
LAND USE PATTERN
EXPLANATION
Cultivated land
Forest and mountain pasture
Waste land (Alpine Tundra Glaciers, some isolated grazing and farming in mountain valleys)

MAP 7. Land use pattern. Compiled from photographs taken from a light airplane with a 35-mm. camera held in the hand.

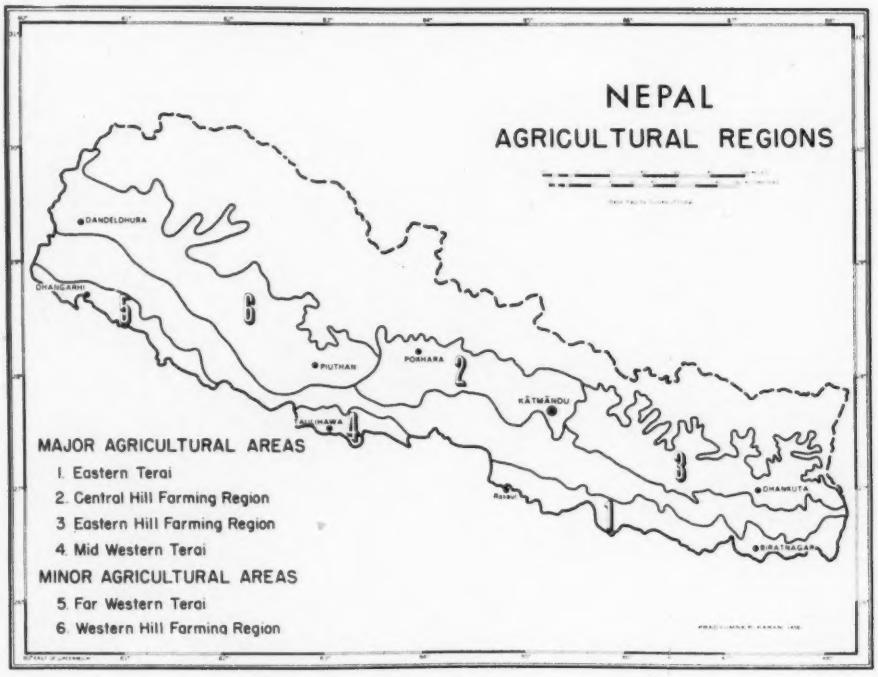
The 35-millimeter color transparency slides obtained by the above method were projected on a screen and land use was transferred from them on base maps of a scale of 1 inch to 4 miles (1:253,440).[14] This simple procedure was most effective for plotting the areal distribution of cultivated land, grazing and forest land, and wasteland (map 6).[15] Other uses of land such as settlements and roads, although important from an economic standpoint, occupy very small areas in Nepal and are therefore not shown on the land use map. For the purposes of this publication the original land use map has been greatly reduced (map 7).

DISTRIBUTION OF CULTIVATED AREA

The land use map (map 7) reveals four major concentrations of cultivated land: (*a*) the subtropical eastern terai; (*b*) the central hill farming region extending from Katmandu Valley to Pokhara Valley; (*c*) the eastern hill farming region; and (*d*) the mid-western terai (maps 7 and 8). Widely scattered patches of cultivated land also occur in the mountain valleys of western Nepal, in the warm dry far-western terai, and elsewhere, but these are unimportant as compared with the four major concentrations of cultivated land noted above.

[14] The quarter inch (1 inch to 4 miles) topographical sheets of Nepal (based on reconnaissance survey of 1924–27) published by the Survey of India were used as base maps for plotting land use from the color transparency slides. The following 28 sheets cover entire Nepal: 63 E, 63 I, 63 M, 72 A, 72 E, 72 I, 72 M, 78 A, 72 B, 72 F, 72 J, 72 N, 78 B, 62 B, 62 F, 62 J, 62 C, 62 G, 62 K, 62 O, 62 P, 62 D, 62 H, 62 L, 71 C, 71 D, 71 H, 71 L.

[15] Successful results with this technique in Nepal have demonstrated that it can be used with advantage in other inaccessible and underdeveloped countries for land use inventory by the professional geographer. On the average in Nepal cost of film and flying was about $0.85 per square mile of the area photographed. My experience in Nepal indicates that with more careful planning (so as to avoid wastage of expensive color film and flying time) the cost could have been reduced a little. Obviously the cost of aero-field work will vary in different countries, but this technique is decidedly quicker and cheaper in underdeveloped areas of the world with poor surface transport facilities.



MAP 8.

Clear delineation of Nepal's agricultural regions would seem to be a starting point for an analysis of the cultivated land. The air photos and the resulting land use map, by permitting direct observation of spacing and intensity of cultivated land, served as a basis for mapping the agricultural regions (map 8). These regions were identified by drawing lines around the areas (on the land use map 7) having distinctive land use and farming characteristics. This categorization of agriculture is admittedly somewhat arbitrary, yet considerable air reconnaissance and mapping in 1957 contributed to the establishment of boundaries.

The eastern terai, falling within the districts of Parsa, Bara, Rautahat, Sarlahi, Mahotari, Saptari, and Morang (map 3), is the outstanding agricultural region of Nepal.[16] This area, forming the northernmost extension of the Gangetic plains of Bihar (India), varies in width from sixteen to twenty miles and consists mainly of alluvium which is rather gravelly in the north. This hot and humid area (map 5) has an annual rainfall of more than eighty inches and is the environment

FIG. 5. Terraced agricultural land characterizes most of Nepal. This scene is ten miles south of Katmandu. The wet lower terraces are used for rice and the drier upper terraces grow corn. Terraced fields such as this follow up every valley in the hill lands of Nepal.

[16] This conclusion arrived by the plotting of land use is substantiated by Rauch in a flight over Nepal: See Emil Rauch, Eindrucke eines Fluges uber Nepal, *Geographica Helvetica* **8**: 316-321, reference on 317, Bern, 1953.

of nature's dense forest and man's rice, jute, and sugar cane. An extended monsoon and heavy rainfall permits the cultivation of two or three crops per year. The chief crops are those which require much water, such as rice and jute. The region has good access to markets in India and exports sizable agricultural surpluses of rice and jute.[17]

The portion of central Nepal extending from Katmandu Valley to Pokhara Valley, comprising the districts of Katmandu Valley, West No. 1, 2, 3, and 4 (map 3) is the second most important agricultural area of Nepal.[18] Here the Mahabharat Range and the mountains of Inner Himalaya enclose several fertile valleys, including the

FIG. 6. Farming methods in Nepal are primitive. In most areas only shallow cultivation with local-type plough is practiced. The ground is turned over, often as deep as 30 centimeters, with a broad, heavy mattock. In this view the soil, turned in large lumps, is being broken up with wooden mallet by the farmer's wife.

famed Katmandu Valley—the heart of the country (fig. 5). The deep alluvial soils of these well-watered valleys are extremely fertile. Both in Katmandu and Pokhara, as in other valleys of this "central hill farming region," agriculture is characterized by small fields, primitive implements (fig. 6), and an intensive subsistence type of rural economy in which rice is the leading crop[19] (fig. 7). The hill slopes are carefully

FIG. 7. Rice is the dominant crop in Nepal. Usually the rice grown on the lower terraces is well cared for. In this scene the weeds are being cleared from the rice fields.

terraced. Cultivated plots in the valley bottoms are indeed small, but those on the extremely steep slopes are narrow, and smaller (fig. 8). In this densely populated part of Nepal (map 9) land use is highly intensive (fig. 9).

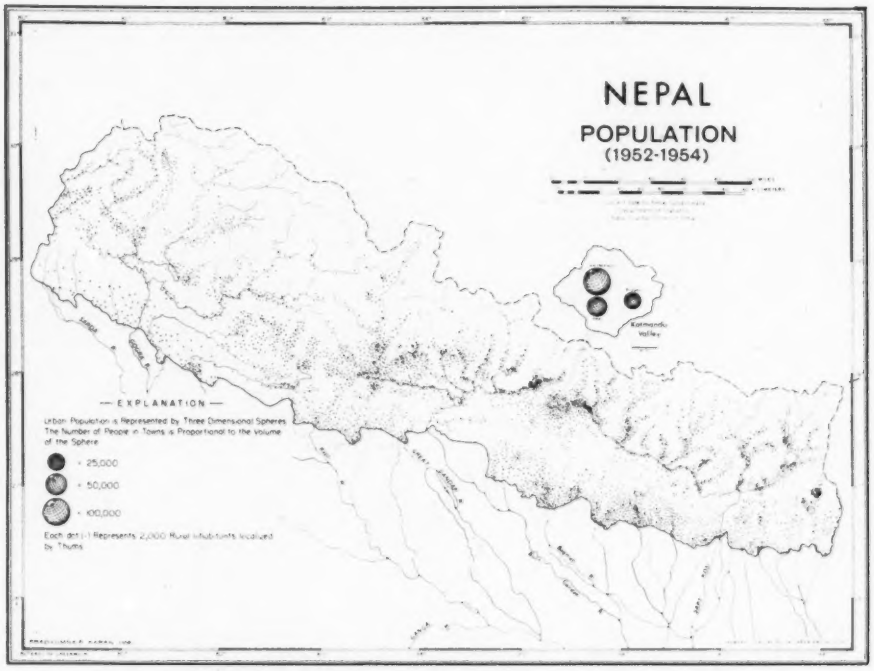
Within the eastern mountains (map 4), which

FIG. 8. Terraced fields on steep slopes are very small. These painstakingly terraced hill slopes reveal the intensity of man's quest for food and reflect the pressure of population on available land. This view is near Gurkha in the central hill farming region. Rice is the dominant summer crop on these terraces wherever natural water is available.

[17] Y. P. Pant, *Planning in underdeveloped economies*, 88, Allahabad, Indian Press Ltd., 1955. Chapter 5 of this book contains a concise summary of the economy of Nepal.

[18] Emil Rauch, *op. cit.*, 318 (footnote 16).

[19] Although space does not permit elaboration on this point, these remarks on rural economy are based on a statistical economic survey of land use and farming methods in ten villages of Katmandu Valley. A full report on the agricultural geography of five of these ten villages is given in P. P. Karan and W. M. Jenkins, *Nepal: a physical and cultural geography*, Lexington, University of Kentucky Press, 1960 (in press).



MAP 9. Distribution of population. Based on official census data.

includes the districts of East No. 1, 2, 3, and 4, Dhankuta and Ilam (map 3), agriculture is concentrated in mountain valleys and along terraced slopes of the Inner Himalayas (maps 1 and 2). Here climate changes with elevation (map 5), and the region may be said to have undifferentiated microthermal climates. Although the land is rough and stony and the weather bitter cold much of the year, agriculture is practiced by Himalayan people such as the Bhotias and Sherpas. Potatoes and barley grow in Khumbu[20] (Chisankhu, East No. 3) mostly at altitudes between eight and ten thousand feet; potatoes, the Sherpa's largest crop, grow at altitudes up to fourteen thousand feet[21] and occasionally even higher. There is a great deal of transhumance, for in the summer the Sherpas take their herds of sheep, goats, and yaks to the higher mountain pastures.[22]

In the lower parts the Limbus, Sunwars, and Rais, who are predominantly subsistence farmers, grow rice, potatoes, and corn. Where there are transport facilities potatoes are exported to India.[23]

In the midwestern terai, comprising the districts of Siuraj, Khajahani, Majhkhanda, and Palhi (map 3), rainfall decreases to about forty inches and is uncertain. In this midwestern portion of the terai the comparative deficiency of moisture limits the intense use of cultivated lands.[24] Because of the lack of rainfall harvests are often poor. The soils and the marketing position are good but cultivation is less intensive than that of the eastern terai.

West of the Kali Gandaki River (map 2), both in the mountains and in the sub-Himalayan

[20] Charles Stonor, *The Sherpa and the snowman*, 170, London, Hollis and Carter, 1955.

[21] Tom Weir, *East of Katmandu*, 103, Fair Lawn, New Jersey, Essential Books, 1956. Weir describes harvesting of potatoes in Imja Khola northeast of Thyangboche.

[22] Ella Maillart, *The land of the Sherpas*, 15, London, Hodder and Stoughton, 1955.

[23] A brief discussion of the farm economy of this area is given by E. Rauch, *Report to the Government of Nepal on farm enterprises*, FAO Report No. 260, 24 pages (mimeographed), Rome, 1954.

[24] For a discussion of the available water supply and how it affects the agricultural use of land in Nepal see S. Theuvenet, *Report to the Government of Nepal on irrigation*, FAO Report No. 162, 43 pages (mimeographed), Rome, 1953.

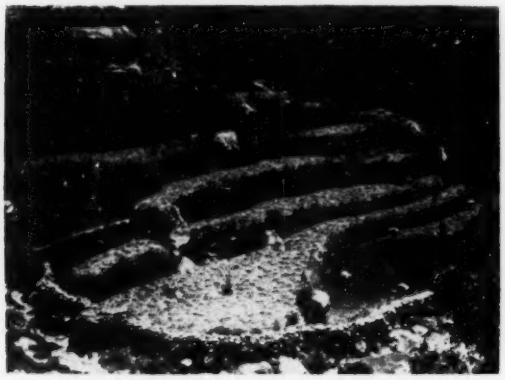


FIG. 9. Most of the farming is done on small holdings by families who try to meet their own basic needs. Many of these holdings, such as this one in Katmandu Valley, are too small to utilize fully the labor potential of the family in possession and are inadequate for family maintenance.

terai plains, areas of cultivated land are widely scattered with no significant concentration. This is largely due to drier conditions (estimated rainfall of about thirty inches annually) which limits the extent of cultivated land. Two agricultural areas may be distinguished in this part of west Nepal (map 8): the warm-dry far western terai falling mostly in the districts of Banke, Bardia, and Kailali (map 3) and the western hill farming region with a wide dispersal of cultivated land in various districts of west Nepal. In both of these regions the soils are fair but because of drier conditions farming is extensive [25] and population is sparse.

Lands presently under cultivation in Nepal include considerable areas which from an ecological and topographical standpoint should be under grass or forest. Contrariwise, areas in west Nepal which are well suited for farming are uncultivated because of lack of irrigation facilities.

GRAZING AND FOREST

Most of the forests [26] of Nepal are located in the foothills and the Inner Himalayan ranges (maps 7 and 1). In the terai plains proper, especially in the eastern and midwestern terai (map 4), areas under forest are comparatively small. In western Nepal more land is in forest, but much of it is unproductive because of overfelling, or overgrazing (fig. 10). Large areas have been burnt in the destructive practice of shifting agriculture.

Pasture is limited in Nepal and forests and other uncultivated lands (fig. 11) are closely grazed [27] making it all but impossible to show the two land uses separately. The pattern is further complicated by the fact that there are scattered areas of shifting cultivation within the forests. On the land use map (map 7), therefore grazing and forest lands have been grouped together. This area also includes strips of cultivated land.

As noted above the total pasture is insufficient for the large cattle population.[28] Fodder crops are seldom grown and cattle subsist mainly on pasture and the leaves of trees. A large number of sheep and goats place an additional burden on the available land with the result that it is heavily over-grazed. This over-grazing is one of the main causes of the destruction of forest and of soil erosion in Nepal. The high Himalayan region contains good pasture, but owing to its topographical position its use for this purpose is limited.

WASTELANDS

Most of the wastelands (map 7) lie in the Great Himalaya above 15,000 feet (map 1).

FIG. 10. A view of the over-grazed forest lands in the Mahabharat Range. Branches of trees are cut for fuel and fodder.

[25] Emil Rauch, *op. cit.*, 319 (footnote 16).

[26] An assessment of Nepal's forest resources is contained in Ernest Robbe, *Report to the Government of Nepal on forestry*, FAO Report No. 209, 66 pages (mimeographed), Rome, 1954.

[27] H. Kihara, editor, *Fauna and flora of Nepal Himalaya*, 289, Kyoto, 1955.

[28] George V. Bowers, *Agricultural development in Nepal*, 27, Washington, D. C., U. S. Dept. of Agric., Foreign Agricultural Service, no date, [1953?] (mimeographed).

FIG. 11. The number of livestock in Nepal (estimated at seven million) almost equals the human population. Grazing of animals on the forests and other uncultivated lands has resulted in a serious erosion problem. Rapid erosion, as seen in this view, characterizes many areas of Nepal.

Here the rugged mountain ranges of the Great Himalaya rise into peaks of perpetual snow. This part of Nepal is undoubtedly one of the most mountainous areas in the world consisting of several fantastic snowy giants of the world like Everest, Kanchenjunga, Makalu, Dhaulagiri, and Annapurna, all above 26,400 feet. Here the climate is truly alpine tundra (map 5). It is practically uninhabited except for small and widely dispersed settlements in the lower parts of the mountain valleys at about 15,000 feet. Because of the rugged terrain and severe climate these lands are practically barren and useless.

POSSIBILITY OF INCREASING THE AREA UNDER CULTIVATION

At this point, when the main uses of land have been considered, it is possible to discuss the question of increasing the area under cultivation. The question is of considerable significance, as increasing the cultivated area is one of the major means (the other being increase in productivity per acre) of raising agricultural production to meet the needs of the growing population of Nepal. On this subject the writer has come to the following conclusions.

Firstly, the possibility of increasing areas under cultivation is extremely limited in the waste lands of the Great Himalayan region because of the rugged terrain and severe climate.

Secondly, there is scope for extending cultivation to a limited extent in some of the forest areas. But against this, there are areas of cultivated land which should be retired from cultivation and brought under forests in order to afford protection from soil erosion and conserve the natural resources of soil and water. The net result would most probably be a decrease in cultivated area and not an increase. The area under forests is insufficient and has to be increased to improve physical and hydrographic conditions for controlling erosion and floods. Any decrease from the present totals cannot be contemplated.

Thirdly, there is an appreciable scope for expansion of cultivation in areas of fallow lands in the terai. Substantial reduction can be made in fallow lands if more intensive cropping methods are adopted and soils are fertilized, so that there is less need for keeping the land fallow. As considerable portion of the fallow land is in the dry areas of western Nepal, extension of irrigation facilities and improvements in dry farming methods are other steps necessary for reducing acreages of fallow lands.

Fourthly, there is scope of expanding cultivated area by land reclamation projects in the marshy and swampy areas of the terai, and by large-scale irrigation projects in the dry areas of western Nepal. The precise figure of additional area available for cultivation by such reclamation and irrigation projects can be determined by detailed land capability surveys. But it is quite clear that the total, whatever it might be, cannot be more than a fraction of the area already under cultivation. It would be reasonable to conclude from the land use reconnaissance that the possibility of expanding the agricultural area is extremely limited in Nepal. Farmers in Nepal have pushed the limits of cultivation as far as they could with the technological means and resources at their command. If certain cultivable lands remain uncultivated, it is mainly because they suffer from serious defects like deficiency of moisture or prevalence of malaria which, though they can be corrected with modern techniques, could not be tackled with the limited resources and rather simple primitive techniques of the Nepalese farmer.

CONCLUSIONS

Now the field geographer can greatly simplify and expedite the land use inventory of substantial areas with the use of a light airplane and an ordinary 35-millimeter camera as an inexpensive and versatile field tool combination. Experience in Nepal demonstrates that the tedious field survey on the ground can be largely dispensed with to

study efficiently, accurately, and speedily land use patterns, characteristics and associations in adequate detail for inventory purposes which is essential in planning agricultural development.

The rapid land use inventory of Nepal by aerofield techniques indicates that increases in Nepalese agricultural production to meet the requirements of her expanding population have to come mainly through increased production (or higher yields) from the lands already under cultivation. Higher yields from the present cultivated land can come through measures like development of irrigation, use of improved seeds, application of manures and fertilizers, proper crop rotations, control of pests and plant diseases, and the whole range of agricultural improvement practices. These measures for increasing agricultural production involve widespread instruction of the Nepalese farmers in the use of scientific techniques of agriculture and rural development.

Increase in agricultural production resulting from expanding the area under cultivation (for example, by reclamation of lands in terai by drainage schemes) will be limited because the additional area which can be brought under cultivation is comparatively small. The pressure of growing population in Nepal has operated to bring under use nearly all cultivable land, including steep hillsides. Small areas can be brought under cultivation by modern engineering techniques of land reclamation which are beyond the limited resources of the Nepalese.

SOME MEDIEVAL AND RENAISSANCE MANUSCRIPTS ON PHYSICS

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THIS paper is devoted primarily to eight manuscripts which contain texts in physics that date from the late thirteenth century to A.D. 1470 and 1474. As it happens, they may be considered simultaneously in roughly chronological order and by the libraries in which they are now found: two at the Bibliothèque Nationale of Paris (BN 15362 and 16621); one at the University of Bologna (BU 1227); another at the Biblioteca Nazionale Centrale in Florence (FN conv. soppr. J.X.19); three at the Vatican (VA 829, 3038 and 2225); and one at the Biblioteca Nazionale of Naples (V.H.190). More incidental reference will be made to some fifty other manuscripts, found in these and a score of other libraries. These eight manuscripts will henceforth be cited by the abbreviated sigla given above in parentheses, and BN and VA will be similarly employed in the case of other manuscripts.

BN 15362

In this manuscript are contained *Questiones de quolibet* by James of Viterbo or Jacopo Capoccio, an Augustinian who died in 1308 as bishop of Naples. The manuscript dates from the thirteenth century and was left to the poor masters of the Collège de Sorbonne by Peter of Limoges, one time fellow of that house, who died in 1304. These questions are in two groups of 22 and 24 respectively (at fols. 1ra–69rb), and the fifth query of the second set (at fols. 44vb–50rb) is whether in matter there are seminal roots (*rationes seminales*) of those things which are made from it.

There should be something to start action in matter, and it is *ratio seminalis*. That there are *rationes seminales* in things corporeal is conceded by all Catholic doctors, since St. Augustine expressly mentioned them in many passages. But there are different explanations as to what is meant by them ("Quid tamen per rationes seminales intelligendum sit diversi diversimode senserunt"). Many say that they are a beginning of form in matter, lest they be forced to hold that form is made from nothing or comes from without, as those have said who suppose a *dator formarum*. But some say that this beginning is the entire form of the thing to be, latent in matter, which is brought into the clear by an extrinsic agent, just as he who removes the rust from silver or another metal is said to manifest the silver or other metal hidden under the rust. And this seems to have been the position of Anaxagoras according to Aristotle. But this superficial explanation is neither convenient nor true, since, as the Commentator says, true generation in things cannot be saved by it.

Others hold that not the whole form is latent in matter but part of it. This opinion too does not save true generation and would make substantial form susceptible to enlargement and diminution. Others say that *ratio seminalis* is incomplete form. This view too fails to save true generation, and does not avoid the difficulty of form being made from nothing, since the form finally educed is different from this incomplete beginning. But if form is in matter potentially and is educed by an extrinsic agent, then it is not educed *ex nihilo*.

James contends that inchoation is not needed, but, if so, it might seem to follow that neither are Augustine's *rationes seminales*. He proceeds to assert that true generation is a change from absolute not being to absolute being ("Vera generatio est mutatio de non esse simpliciter ad esse simpliciter").

Some say that *ratio seminalis* is only a passive potentiality existent in matter; others, that it is active potentiality which cooperates with the extrinsic agent, since semen implies active force, and so that generation will be natural and not violent. It is not, however, a beginning of form but active in inducing form in matter. So, according to these, *ratio seminalis* is active potentiality alone. Passive potentiality, as they say, should not be called *ratio seminalis*, but *ratio obedientialis*. It is two-fold in matter: one with respect to the natural agent, and this is natural passive potentiality; the other with respect to the supernatural agent or God, and it is called *potentia vel ratio obedientialis*.

But since according to this position it seems to follow that the same is active and passive, while

active potential force is in the matter of the thing to be made, therefore others say that *rationes seminales* are active virtues, not indeed existent in the matter of the thing to be made, but existing in the extrinsic agent. Furthermore, according to them, the passive potentiality existent in matter is called *ratio seminalis*, albeit not so properly as active potentiality. Both may also be called causal *rationes*. But not all causal *rationes* are seminal, for example, the *rationes ydeales* which exist in God. After the day of judgment there will be no more *rationes seminales*, as generation will then cease. But Augustine, *De trinitate*, III, 8, calls *rationes seminales* causes, because, just as life is produced in the foetus, so the world itself had to be brought into being by causes of things born.

After spending some time in efforts to define first *ratio* and then *seminalis* which seem none too successful, James proceeds to his own conclusion with regard to *rationes seminales*. Aristotle held that there was form in matter potentially before it existed actually, and that it was not caused from outside. This opinion of his is true so far as all natural forms are concerned except the human soul, which, according to Catholic doctors, is induced from without by creation and not educed from the potentiality of matter. The Commentator in First Philosophy seems to say that potentiality differs from the essence of matter, while in *De substantia orbis* he says that potentiality is the very substance of matter. So some say that potentiality is twofold. But James prefers to reconcile the apparent contradiction by explaining that all Averroes meant was that matter is substance potentially. Form is substance in actuality as matter is potentially. Mere lack is insufficient to constitute potentiality; there must also be aptitude and fitness. Matter not merely lacks form but is ready for form. For one form it may be in proximate potentiality; for another, in remote potentiality. One may speak of appetite of matter. Inchoation of form is nothing else than form itself in potential being. Whence it is concluded that form itself in its essence preexists in matter, not indeed actually but potentially, and in generation is drawn by the agent from potentiality to actuality.

After solving nine doubts which arise (fols. 47va–48vb) James affirms that the active virtue which is *ratio seminalis* is a quality, then concludes by noting how his solution agrees with or differs from those which he had previously set forth.

Of a *Practica geometrie* at fols. 201ra–209ra I treat elsewhere.[1] The rest of the contents of the manuscript are medical or logical.

BN 16621

Of our next manuscript Pierre Duhem wrote in his *Études sur Léonard de Vince* **3**: 411, 1913:

> Le manuscrit n° 16621 du fonds latin de la Bibliothèque Nationale est un recueil de cahiers où, vers la fin du xiv^e^ siècle, un élève de l'Université de Paris a consigné une foule des notes; le désordre de ces notes est grand et l'écriture en est tracée avec peu de soin; elles fournissent, cependant, de précieuses indications à qui prend patience de les déchiffrer; celui qui les a rédigée, en effet, y a réuni tous les renseignements qu'il avait pu recueillir sur les doctrines en vogue à l'École d'Oxford. Parmi ces renseignements se trouvent, en particulier, des extraits fort étendus de la *Summa* du Dulmenton; c'est à ces extraits que nous avons dû, tout d'abord, la connaissance de certaines théories développées en cette *Somme*.

In *Le système du monde* **4**: 33, 126, 1916, Duhem used the same manuscript for the *Fractiones* of Jean des Murs, composed in 1324, and for

> les discussions échangées par Buridan, en 1335, sur la division à l'infini, la réalité du point et divers autres problèmes, avec un certain maitre M. de Montiscalerio.

Professor Marshall Clagett has microfilms of portions of the manuscript which include texts or fragments by Richard Suiseth (Swineshead)[2]

[1] Thorndike, Lynn, Notes on some astronomical, astrological and mathematical manuscripts of the Bibliothèque Nationale, Paris, *Jour. Warburg and Courtauld Institutes* **20**: 112–172, 1957.

[2] Clagett, Marshall, Medieval mathematics and physics: a check list of microfilm reproductions, *Isis* **44**: 380, 1953: "Richard Swineshead . . . De motibus naturalibus (De primo motore) . . . BN 16621, 52r–v, 130v–139r (fragments)." Clagett, Marshall, Medieval mathematics, physics and philosophy: a revised catalogue of photographic reproductions, with the assistance of John E. Murdoch, *Manuscripta* **3**: 32, 1959: "De motibus naturalibus (perhaps by a Roger Swineshead, distinct from Richard?) . . . BN 16621, 14r–84v (with leaves of calculation interposed) B–98(2)."

In the MS itself I noted:

25v Explicit questio de gradibus.
Opus Suiset de primo motore 8° differentiis distinguitur prout patet in processu eiusdem
26(36)r top margin. 3us sisternus de primo motore Suiset sequitur in tribus quaternis
52r top margin. 2us de Suicet
53r top margin. Suicet 2us quolibet
60r top margin. Queritur de latitudinibus rerum . . .
66r top margin. Queritur de augmentatione. Suicet quaternus 2us
78r top margin. Suicet quaternus 4us et ultimus
84v the text breaks off in mid-page.

and an anonymous *Expositio super de proportionibus* (at fols. 212v–213v) based on the work of Thomas Bradwardine,[3] which terminates before it.

A table of contents in French is pasted inside the front cover of our manuscript, and its first item, opening, "Circa influentian agentis (rather than *agentium* as given in the table of contents) . . ." would seem from Little's *Initia*[4] to be Roger Bacon, *De multiplicatione specierum*, but in Little's later bibliography of Roger's works the identification seems more dubious.[5] The ensuing text appeared to deal with the topic of species up to 24v, but fol. 25 was in a different hand, although still as illegible as before. But at the bottom of 25v could be made out, "Explicit questio de gradibus," which seemed to mark the close of a different treatise.

The next leaf was numbered both 26 and 36; the one after it, 37 only. The Suiseth text to 84v was interrupted at 62–64 by the *Fractiones* of Jean des Murs, and followed by particular questions:

85r Utrum omnis motus uniformiter difformis correspondeat suo gradu medio[6]
87r Utrum sit maximum pondus quod homo potest . . .
92v . . . sic de isto dubio de maximo et minimo sit dictum.

Fol. 93r is blank, and only with 93v do we reach the second item of the aforesaid table of contents: "Traité des proportions par Nicolas Oresme." At the top of the page is written

Sequitur tractatus proportionum Orem cum quodam tractatu astrologico, Ad peluca(pauca) aspiciens habito ab illo de Muris item exepta de efmion (Exafrenon?) de proportione motuum in velocitate pene consimilia

which appears to be intended as a sort of combined titulus for the next two or three treatises. The rest of the page is left blank. On 94r the prologue of Oresme's treatise on proportions opens as usual: "Omnis rationalis oppinio de velocitate motuum potest eam sequi aliquam proportionem . . ." and states the themes of the six chapters as

1 a preamble laying down principia
2 conclusiones aliquas de proportionibus, et subiungam quedam practica documenta (97r–
3 de proportionibus proportionum specialius (102r–
4 prius dicta ad proportiones motuum applicabo 105v–
5 on velocities (107r, reaching the seventh conclusion only at 109r
6 incommensurability of celestial motions.

At 110v–114r the third item of the cover's table of contents, "Traité d'astrologie, principe, Ad pauca aspiciens difficili . . ." which had been dimly adumbrated in the aforesaid titulus at 93v, was entitled in Latin, "De astrologia aliqua specialia."; opened, "Ad pauca aspicientes de facili enuntiant . . ." and turned out to be Oresme, *De motibus spherarum*.[7]

The fourth item in the French table of contents, "Traité du mouvement locale," immediately follows at fol. 114v, as *De motu locali*, opening, "Sequitur dicere qualiter motus sequi proportionem . . . ." But the fifth item, "Traité du point par Jean Buridan contra Montiscaleno," does not come until 196r–203v. Meanwhile at 139v began "Sumpta de articulis magistri Nicolay de Ultricuria ab eodem publice revocatis,"[8] numbered 1 to 6, and then 10 to 33; at 180v, a list of Utrums; at 188r–190r:

In primo libro determinatur (?) de toto mundo . . ./ . . . libellum particularem de his in tractatu Burley. Explicit secundus.

and other texts or fragments.

[3] A much longer Expositio tractatus Thomae Bradwardini in omnem motum successivum is found in a MS at St. Marks, Venice: VI.30 (Valentinelli X.219), fols. 77ra–111vb, in two parts, opening, "Tractatum Tome Beduardini expositurus in quo de proportionibus motuum investigat. . . ." I quote this incipit from the MS; Professor Clagett has a microfilm, C–6.

[4] Little, A. G., *Initia operum latinorum*, 1904, citing another MS, Oxford, University College 48, seventeenth century, which is probably a copy of British Museum, Royal 7.F.VIII, of the late thirteenth century. Roger Bacon's *Communia naturalium*, Greek grammar, *Compendium studii theologie*, and Computus are followed at fol. 62 by "Primum caput circa influentiam agentis . . ./ . . . quamquam bene retineat receptum. Explicit tractatus magistri Rogeri Bacon de multiplicatione speciei."

[5] *Roger Bacon Essays*, p. 386 et seq., 1914. In the Index of Incipits we find only "Primum igitur capitulum circa influentiam agentis . . ." from Royal 7.F.VIII, while the University College MS is mentioned only in connection with other works.

[6] It is again found separately at St. Marks, Venice, VIII.19 (Valentinelli XI.19), fifteenth century, fols. 231–234.

[7] Also found, with the variant incipit, "Ad pauca respicientes . . ." at the British Museum, Sloane 2542, fifteenth century, 55v–59r (reproduction 175 at Columbia University); Erfurt, Amplon. Q.385, fourteenth century, 155r–158v; Vatic. Palat. lat. 1345, fifteenth century, 223va–237rb, and 1354, fol. 233v.

[8] Rashdall, Hastings, Nicholas de Ultricuria, a medieval Hume, *Proceedings Aristotelian Society*, London, 1907; Leffe, Jos. Nikolas von Autrecourt, sein Leben, seine Philosophie, seine Schriften, *Beiträge zur Geschichte der Philosophie des Mittelalters* **6**: Heft 2, 1908.

The exposition of Bradwardine already noted is followed at 214r by a text with the unfamiliar incipit, "Quia est in mentibus hominum. . . ." Presently come more utrums in a larger and more legible writing:

224r Queritur utrum adhamas possit attrahere ferrum . . .
225r Queritur ergo utrum motus ferri ad adamantem sit motus animati corporis . . .
225v Queritur ergo utrum movens sit simul cum moto . . .

Fols. 228r–232v are vellum, unlike the rest of the manuscript. After them in the top margin of 233r is the running head, "et sensato," but since there is no "De sensu" to go with it on either 232v or 227v, we appear to be in the midst of a new text.

The sixth and last item of the manuscript's own table of contents is "Extraits de Thomas Bradwardin," while Delisle[9] placed at fol. 237 a "Questio determinata per mag. Bridam a. 1335."

At 238r the incipit, "Utrum sit dare primum et ultimum instans rei permanentis in esse . . ." is that of the work of Walter Burley on this question. At 240v, "Explicit questio determinata a magistro Galcero debularum deo gratias amen," seems to offer a feeble attempt at his name. After a series of questions, some of which are logical, our manuscript concludes at 286r–295v, with a treatise written in a different hand from any yet employed and of which I know of no other copy:

Inter agens infinitum et passum finitum nulla est proportio . . . . . ad actus regularios qui sunt ambulare et consimilia.

BU 1227

BU 1227, of the fifteenth century, opens with the Questions of Jean Buridan on the first three genuine books of the *Meteorologica* (99vb . . . et hec de questione et commentis tertii libri Metheororum magistri Iohannis Bridani, deo gratias), of which manuscripts are fairly numerous,[10] although it has not been printed. Our manuscript closes with James of Forlì on Intension and Remission at 173ra–222vb, opening, "Questio est utrum intensio forme fiat per addicionem partis formalis ad partem formalem. . . ." It is in three parts:

180va Et hec de prima parte tractatus huius breviter dicta sufficiant
216rb Explicit 2a pars huius tractatus. Incipit 3a pars et ultima cum dei laude.[11]

Between these two well-known works come Questions of a Master Mesinus, doctor of arts and medicine, on a question by Iohannes de Casali:

101ra–163va: Postulato dei suffragio necnon eius genetricis virginis Marie et beatorum apostolorum Petri et Pauli tociusque curie celestis . . . . . Expliciunt questiones edite per magistrum Mesinum artium et medicine doctorem eximium super questione magistri Iohannis de Casali.

Questions by this same Mesinus, or Messinus, as the name is spelled by Valentinelli,[12] Clagett,[13] and Curtis Wilson[14] on a question of the same John de Casali, are found in two manuscripts of the same century and roughly the same length, at St. Marks in Venice and at the Escorial. Although I have not seen these two manuscripts, and others differ as to their subject, Valentinelli stating anent the Venetian manuscript, "Quaestio Ioannis de Casali est de latitudine formarum," while Clagett describes the questions of Messinus as "Super questione Johannis Casali de motu," and Wilson as a "commentary on John of Casali's De velocitate motus alterationis," I have little doubt that all three manuscripts contain essentially the same text. Valentinelli's variant incipit, "Queritur utrum bene distribuatur (?) hic titulus, latitudo uniformiter difformis . . ." corresponds

[9] Delisle, Léopold, *Inventaire des mss latins conservés à la bibliothèque nationale sous les numéros 8823–18613 et faisant suite à la série dont la catalogue a été publié en 1744*, Paris, 1863–1871. Or see *La bibliothèque de l'École des Chartes* **31**: 135–161, on Latin MSS 16255–16718. The summary of the contents of 16621 is very brief.

[10] Schum, Wilhelm, *Beschreibendes Verzeichniss d. Amplon. HSS-Sammlung zu Erfurt*, 571, Berlin, 1887, and Coxe, H. O. *Cat. cod. Canonicanos*, Oxford, 1854, col. 785, for mss Q.342, 69–130, and canon. misc. 462 respectively, repeat ascriptions to Buridan of Questions which are rather by pseudo-Scotus. See my: Oresme and fourteenth century commentaries on the Meteorologica, *Isis* **45**: 145–152, 1954, and: More questions on the Meteorologica, *Isis* **46**: 357–360, 1955.

[11] Frati, Lodovico, Indice dei codici latini conservati nella R. Biblioteca Universitaria di Bologna, *Studi italiani di filologia classica* **16**: 103–432; 17, 1–171, Florence, 1908–1909, quotes from the colophon: "Explicit tractatus de intensione et remissione editus a Iacobo Forliviense doctore illu. completus scribi a me Petro de Frontonio cordiali amico magistri Elpidii cuius est liber iste 1431, die 21 octobris," but omits the further interesting statement: "de mane per horam unam antequam fieret sermo pro principio studii."

[12] Valentinelli, J., *Bibliotheca manuscripta ad S. Marci Venetiarum*, 6 vols., Venice, 1868–1876, discussing MS VI.225 (XI.21).

[13] *Manuscripta* **3**: 27, 1959.

[14] Wilson, Curtis, *William Heytesbury*, 27, 1956.

to Mesinus's first question in our manuscript, "Utrum hic terminus latitudo bene describatur?" Mesinus had previously stated that on some matters John spoke truly but on others seemed open to criticism.

Eight leaves later he is still on the subject of latitude, and his fifth query, Whether all uniformly difform latitude corresponds to its mean degree, is argued at great length. The next question, unnumbered in our manuscript, asks whether any agent can act more swiftly on a more distant part than on a part which is less distant. The question after it is whether any luminous body acts with equal speed on a remote and a nearby part. Numbering of the questions is resumed with the seventh which inquires whether it is possible that a luminous body of any size and minor degree of light produce an equal latitude of light to a luminous body of greater quantity and intenser light. The eighth question concerns the termination of uniformly difform latitude; what should be the eleventh, at 158 vb, the velocity of motion.[15]

FN CONV. SOPPR. J.X.19

Since Björnbo in cataloguing this manuscript (formerly Codex S. Marci Florent. 202)[16] merely gave titles, incipits and desinits of its component treatises on perspective and other physical topics, some further account of their content may be added, especially as most of them are anonymous or of dubious authorship, or found only in this manuscript of about A.D. 1400 or somewhat earlier. He described its opening treatise thus:

fol. 1r–2v: leer
1. Perspectiva (fol. 3r–29r).
Titel (unter fol. 3r): Tractatus primus de puncto(!)
Anfang: Philosoforum non nulli ab oculo radios visuales exire.[17]
fol. 17r: Incipit secundus tractatus qui est de angulis ubi plurima et singularia de eo tangunt[18] . . .
Schluss: . . . reuolutiones Venus[19] numerus terminabitur quantitatum.
fol. 29v–30v: leer.

This description overlooks the fact that the work is divided into three tractates on point, lines and angles. At fol. 4v, in the bottom margin, is written, "De lineis Tractatus Secundus," so that the "Incipit secundus tractatus qui est de angulis . . ." at fol. 17r, top margin, which Björnbo quoted, obviously should read, "Incipit tertius tractatus. . . ." Other captions, mostly marginal, are as follows:

4r Utrum punctus visu determinatur
7v Utrum recta linea videri possit recta
Utrum alique linee videri possint eque distantes
8r Utrum non eque distantes videri possint eque distantes
10v Utrum aliqua linea videatur tanta quanta ipsa est
11v Utrum aliqua linea possit videri tanta quanta ipsa est duobus oculis diversos situs habentibus
12r Utrum aliqua curva videatur tanta quanta ipsa est
14r Utrum aliqua linea videatur diameter alicuius circuli oculo situ alicubi in terre (?) circumferentiam
15v Utrum oculo existente in centro periferie videntur circularis figura
18v Utrum omnes recti (anguli) sint equales
23v De apparentia anguli
25r De angulo soluto (solido?)
25v Quid sit angulus
26r De angulis due positiones circa diffinitionem eius (?)
26v Putant nonnulli quod angulus sit quantitas in superficie subiectata
27v Artificium quo docetur datum angulum secundum quamlibet proportionem dividere.

The second treatise in our manuscript, at fols. 31r–42r, another anonymous *Perspectiva*, is found also in a manuscript at Bruges, 530 of the fourteenth century, at fols. 31r–40v. The opening words are the same in both manuscripts, "Plato in Timeo (Thimeo in Bruges 530) volens reddere causam propter quam visus inest nostris oculis. . . ." But the desinit in the Bruges manuscript, ". . . lucifer et quanto quam lucifer aurea phebe," differs from Björnbo's ". . . lux lucifere et quesitus quesite lucifere aurea phebe." The bearing of these words is that the author has just remarked:

> These few things are said to excite the minds of youth to speculation on noble themes, and with humble subjection to the correction of the reverend masters of this most excellent University of Paris, and especially to that of the venerable doctors of the faculty of arts, in whom in these evil times, as in precious vessels, is guarded the pearl of philosophy, and whose doctrine is a light as much more splendid as Lucifer is than other stars or as golden Phoebus is than Lucifer.

This shows that the treatise emanates from the University of Paris, and reference was earlier made in it to a disputation on vision of the stars

[15] 139ra, Queritur nono . . .; 149va, Queritur decimo; 161rb, Queritur duodecimo.

[16] Björnbo, A. A., Die mathematischen S. Marco-handschriften in Florenz, *Bibliotheca mathematica*, 3 Folge, **12**: 202–204, 1912. The manuscript itself he described with sufficient fulness.

[17] Add, ponebant.

[18] In the manuscript, tanguntur.

[19] Probably this should be Veneris; I neglected to verify it.

held "apud sanctum Bernardum," a reference presumably to the Collège des Bernardins at Paris. Aratus is quoted, Alhazen is cited, and Witelo is cited repeatedly.

Passing over the third constituent of our manuscript, which consists of only four lines from Nicole Oresme on the same topic of vision of the stars, we come to the Questions on Perspective of Dominic of Chivasso (at fols. 44r–55v). He is well known for his *Practica geometriae*,[20] and I have noted elsewhere his astrology and commentaries on the *Sphere* and *De celo et mundo*.[21] But little attention has been paid to his Questions on Perspective, of which this would seem to be the sole manuscript. Björnbo's brief and indistinguishable incipit, "Queritur primo . . ." should be enlarged to "Queritur primo utrum tota perspectiva consideret de linea visuali. . . ." Other questions are:

44v Secundo queritur utrum luces et colores illuminati (immediate?) agunt in visum
47r Queritur 3° utrum visibilia diversimode appareant visui propter diversificationem lucis
49v Queritur 4° utrum organum virtutis visive sit spericum ex tribus humoribus et quatuor tunicis compositum
51v Queritur 5° utrum visio fiat secundum piramidem
54r Utrum omnia visibilia mediate visui corpora equaliter cognoscantur[22]

Questions on perspective by Henricus de Langenstein (Henry of Hesse) at 56r–85v, opening, "Utrum lux multiplicetur per radios? Arguitur[23] quod non . . ." are based on the *Perspectiva communis* of Peckham, and are found in other manuscripts at Erfurt[24] and Vienna[25] and in an edition of 1503.[26] In our manuscript and that at Erfurt, judging from their similar desinits,[27] the last question on the rainbow is not reached.

[20] Sarton, George, *Introduction to the history of science* 3: 641–643, 1947, with further bibliography.

[21] *Isis* 13: 69–70, 1929; *Magic and experimental science* 3: 587–588; *The Sphere of Sacrobosco*, 37, 1949; *Scriptorium* 7: 81, 1953.

[22] As Björnbo noted, a leaf has been torn out between those now numbered 54 and 55.

[23] Not *dicitur* or *queritur*, as suggested by Björnbo.

[24] Amplon. F. 380, late fourteenth century, fols. 29–40; where it is ascribed to Oresme.

[25] Vienna, Nationalbibliothek, Latin ms 4992, fifteenth century, fols. 169v–172v.

[26] See my: *Magic and experimental science* 3: 509–510.

[27] Schum's ". . . contingant convexitatem 2ᵉ periferie, scilicet viridis," seems preferable to Björnbo's ". . . contingant que 2ᵉ periferie scilicet radis."

Our manuscript now leaves the subject of perspective for questions as to maximum and minimum, of which it seems the only known copy. Those at 88r–95v, "exbarit (?)" are perhaps meant to be "ex Burit" or from Buridan. Beginning with the propositions:

Quod non sit dare maximum quod Sortes suficit portare . . .
Quod sit dare minimum quod Sortes non suficit portare . . .
Quod non sit dare maximum tempus per quod antichristus poterit esse futurus . . .
Quod non sit dare minimum tempus per quod antichristus non poterit esse futurus . . .,

the text has by 92r reached the theme of *primum instans*, by 94r is discussing resistance, and, on 95r, *potentia*. It ends: ". . . possibile est antecedens verum et consequens falsum."[28]

What Björnbo catalogued as more questions on maximum and minimum at 96r–112r, I did not examine further than to see that his incipit, "De diversis diffinitionibus esse . . ." should be altered to "De diversis diffinitionibus circa rationes (?) potentie active. . . ." Also his form of incipit for the final question at 112v–114v on velocity of alteration should be changed from "Utrum velocitas alt'ois habet ad tande pones maximam latitudinem forme que . . ." to "Utrum velocitas alterationis habet adtendi penes maximam latitudinem. . . ."[29]

VA 829

Long before Cardan rejected fire as a fourth element, an anonymous *Questio* in this manuscript of the fourteenth century had debated whether there was a sphere of fire between that of the air and that of the moon.[30] One of the disputant's arguments to the contrary was that such a sphere of fire would be *otiosa* (idle, useless, without purpose) and that nothing in nature is such. Also fire requires pabulum for its conservation, and there would be none in a sphere of pure fire. He recognizes, however, that his opponents may say that fire needs fuel only when it is outside its own sphere. But he further contends that, if there is

[28] Björnbo failed to decipher the abbreviations for *antecedens* and *consequens*.

[29] It should be explained that Björnbo's death had prevented his correcting proof of this last of his valuable series of articles on the mathematical S. Marco manuscripts at Florence.

[30] VA 829, 135v–137r: "Queritur utrum inter substantiam orbis lune et aerem sit spera ignis media. Quod sic, quia si unum contrariorum est in natura et reliquum . . ./. . . si possent ibi sine pabulo conservari."

a sphere of fire, it should give off light and heat, which it does not do. He also asks why it has no inhabitants, whereas there are fish in water and birds in the air. In this connection he considers the familiar problem whether the salamander can live in fire. His conclusion is that what the philosopher (Aristotle) calls the sphere of fire is merely that part of the sphere of air which is next to the celestial spheres and is heated by the velocity of their movements.

VA 3038

The name of William Hentisbery or Heytesbury is now recognized as of importance in the history of science,[31] upon which even those of his works of a seemingly purely logical character are seen to have their bearing.[32] Our manuscript, a paper octavo of the fourteenth century, contains two tracts by him which were not noticed in *A Catalogue of Incipits of medieval scientific writings in Latin*,[33] which gives the opening words of half a dozen other treatises from his pen. At 15r–22v his *De sensu composito et diviso* opens and closes:

Arguendo a sensu composito ad sensum divisum . . ./ . . . Explicit tractatus de sensu composito et de sensu diviso valde utilis secundum Hentisberum. Amen.

It was printed in 1491, 1494 and 1500,[34] and is summarized at length by Curtis Wilson,[35] who lists eight manuscripts of it[36] but not ours, although he elsewhere cites other portions of it.[37] It perhaps comprises some of the "little treatises" which were included in the incunabula editions under separate titles.[38] The other item by Heytesbury in our manuscript is *Five Cases* at 37v–39r,[39] opening and closing:

Isti sunt casus Heresberi. Item ponatur talis casus quod heri viderim Sortem et nullum alium a Sorte te videamus (?) . . ./. . . Expliciunt quinque casus Herisberi valde boni.

The former of these two texts by Heytesbury is preceded at 1r–13r, opening the manuscript, by the *Speculum iuvenum* of Richard Billingham, with its usual incipit, "Terminus est in quem resolvitur propositum . . ." but with an explicit more peculiar to our codex:

Explicit tractatus magistri Ricardi de Belligam qui Speculum iuvenum nuncupatur, et dicitur Belligam quasi bella cantans vel cantator veritatis vel falsitatis propositionum.

The work was sometimes called *Speculum puerile*.[40] Richard Billingham was at Merton College, Oxford, a little later than Heytesbury, between 1344 and 1356, and in 1349 was involved in a riot in connection with the election of the chancellor.[41] His *Speculum iuvenum* and *Conclusiones* are found in another manuscript at the Vatican (VA 3065, 6r–11v, 21r–25r),[42] and there are several late fourteenth- and early fifteenth-century copies of it and other works by him and a commentary on his *De probationibus terminorum* in the Amplonian collection at Erfurt.[43]

Between the two tracts by Heytesbury in our manuscript come *Obligationes* of Petrus de Candia, who in 1409–1410 became pope Innocent V.

22v Rogasti me karissime ut tue in crucifixi latere caritati aliquas regulas artis obligatorie in unum opusculum colligerem . . .

[31] Sarton, *Introduction* 3: 565–566, 1947. Clagett, *op. cit.*, lists microfilms of eight works ascribed to Heytesbury.

[32] Wilson, Curtis, William of Heytesbury: Physical problems in medieval Sophismata, a doctoral dissertation at Columbia University, since published in revised form as *William Heytesbury: Medieval logic and the rise of mathematical physics*, Madison, 1956.

[33] Thorndike, Lynn and Pearl Kibre, 1937.

[34] Klebs, A. C., *Incunabula scientifica et medica*, p. 174, Nos. 514.1, 514.2, 1938; Stillwell, M. B., *Incunabula in American libraries*, 239, Nos. H50, H51, 1940. Wilson, *op. cit.*, mentions that of 1500.

[35] *Op. cit.*, 13–18.

[36] *Ibid.*, 206.

[37] *Ibid.*, 214.

[38] At fol. 19r–v is written: "Hic docetur (19v) egregie de scire et dubitare." One of the "collection of six little treatises" which constitute Heytesbury's *Regulae solvendi sophismata* is entitled, "De scire et dubitare": Wilson, *op. cit.*, 5; ed. of 1494, 12va–16va.

[39] Although Wilson, op. cit., 214, lists these fols. under "Manuscripts cited," I have failed to find anything corresponding to them in his index or notes.

[40] So in Bale, John, *Index of British and other writers* . . . edited by Reginald Lane Poole, with the help of Mary Bateson, 340, (where nine works by Billingham are listed with their incipits) Oxford, 1902; likewise in a manuscript at Klagenfurt, Bischöfl. Bibl. XXIX.e.1, 38v–44v: "et est finis huius tractatus Anglicani, anno 1385 finitus est iste liber magistri Richardi de Biligam in translatione Luciae virginis." Wilson, *op. cit.*, p. 171, note 20, lists our manuscript but gives the title as "Tractatus de veritate et falsitate propositionis," apparently from another manuscript of it, Florence, Bibl. Naz. Centrale, V.43.

[41] See the article on Billingham by R. L. Poole in the *Dictionary of National Biography*.

[42] *Bull. int. de l'Acad. des Sciences de Cracovie*, Classe de philologie. Classe d'hist. et de philos., 112, 1927–1928.

[43] Schum, *Verzeichniss*, MSS Q.30, Q.241, Q.256, O.71, O.75, D.13a.

24v Ut autem sciatur quid est formale inpertinens . . .
37v Expliciunt Obligationes magistri Petri de Candia multe bone et utiles.

This logical treatise presumably antedated Peter's theological questions on the *Sentences* of Peter Lombard, which he delivered at Paris in 1380 and subsequently and of which manuscripts are more common.[44]

Following Heytesbury's *Five Cases* are somewhat more than four pages of writing, with some blank spaces intervening, so that there seem to be four brief tracts or distinct extracts, perhaps also by Heytesbury.

VA 2225

A treatise by a Simon Geminius occupies the first leaves (1ra–8vb) of this manuscript, which brings together a number of treatises, some of which are significant in the history of medieval physics, others for that of medicine.[45] Since all the others antedate Geminius, we shall consider them first. At 11ra–37va is the Question of Giovanni Marliani on the proportion of motions in velocity.[46] Later on, at 130vb, are

Quedam agumenta Iohannis Marliani in sua questione, Utrum proporcio velocitatum in motibus sit equalis proporcionibus potentiarum motivarum ad suas resistentias?

At 37vb–52rb is a commentary on a treatise by Peter of Mantua, who flourished about 1392–1400,[47] which is here called *De incipit et desinit*. Since this appears to be simply another form of title for Peter's *De instanti*, it is tempting to conclude that the anonymous commentator is no other than the aforesaid Marliani, who twice mentions his *Annotationes in librum de instanti Petri Mantuani*.[48] The commentary is here written in a different hand from the *Questio* by Marliani which precedes it, but most of the component tracts of the manuscript are in different hands, so that it may be argued that the collector who brought them together felt that *Questio* and commentary were related. The commentary is again associated with writings of Marliani in a manuscript at Venice (St. Marks VI.105; Valentinelli X.218), in which the first 41 leaves are occupied by four of Marliani's works, while the commentary occurs at 163–178, but not in immediate juxtaposition to the others.

"Dicemus naturaliter loquentes," written in large letters, are the opening words of Peter's text, not of the following commentary which begins, "Primo magister notanter dicit Naturaliter loquentes. . . ."[49] Peter's text opens similarly in MS Ashburnham 1348, anno 1410, 2ra–10va, of the Laurentian library at Florence:

Dicemus naturaliter loquentes quod sola forma secundum se et quodlibet sui potest incipere esse vel desinere esse . . . /. . . Explicit tractatus de instanti secundum magistrum Petrum de Mantua.

A manuscript at Columbia University, 23 (X.570 P44), anno 1458, inserts an *igitur* after the first word of the incipit, and a Venetian codex has *prius* (St. Marks VI.128, anno 1424, 81–93). An alternative form of title, *Super primo et ultimo instanti*, appears in the colophon of another commentary on it:

Explicit tractatus egregius celeberrimi ac subtilissimi doctoris Appinari famosissimi super primo et ultimo instanti Petri Mantuani subtilissimi, transcriptus per me Franciscum Pistoriensem cum artibus in Perusino studio operam darem anno domini MCCCCLXXIII.[50]

"Appinari" doubtless stands for Apollinaris Offredi of Cremona, whose defense of the common opinion as to the first and last instant against Peter of Mantua was printed in 1478[51] and

[44] Erfurt, Amplon. F.106, 247 fols.: "Explicit lectura supra sent. frat. P. d. C. ord. Minor. a.d. MCCCLXXX compilata tempore quo Parysius legebat sentencias . . ."; also F.94, a copy of a.d. 1402. At Venice S. Marco L.cvi (Valentinelli III.110) is a copy made in 1380, with a full note of sale of the manuscript in 1399, of Peter's lectures at Paris on the first book of the *Sentences;* while in L. cvii (III, 111) his Paris lectures on the second book are dated 1390.

[45] The three texts in this manuscript by Marliani, Jordanus de Turre and Geminius were noted, but only very briefly, in my Vatican Latin maniscripts in the history of science and medicine, *Isis* **12**: 53–102, sections 52, 56, 79, 1929.

[46] Treated at length by Clagett, Marshall, *Giovanni Marliani and late medieval physics*, 29–30, 139 *et seq.*, 1941.

[47] His name appears in the extant rolls of the faculty of arts and medicine at Bologna as teaching natural philosophy in 1392–1393, moral philosophy in 1395–1397, and both natural and moral philosophy in 1398–1399. The rolls for the academic years 1389–1392, 1393–1395, and 1399–1404, are missing: Dallari, U., *I rotuli dei lettori legisti e artisti dello studio Bolognese*, 4 vols., Bologna, 1888–1924.

[48] Clagett, *op. cit.*, 27, who, however, says further: "No edition, manuscript or printed, of such a work has been found."

[49] Thorndike and Kibre, *op. cit.*, col. 194, item 5, should be corrected accordingly.

[50] Lami, Giov. *Catalogus codicum mss. qui in bibliotheca Riccardiana Florentiae adservantur*, 319, ms L.I.vi, Leghorn, 1756.

[51] Stillwell, *Incunabula in American libraries*, 054.

again in 1482.[52] He is said by Tiraquellus to have composed a *Practica* and other works under Eugenius IV (1431–1447),[53] while Simon de Phares, writing at the close of the century, says under the year 1442, "Apolinaris Cremonensis fut moult aprecié en ce temps pour la science de astrologie," but that he has been unable to run across any books written by him.[54] However, his commentary on Aristotle's *De anima* is preserved in a manuscript of 1445 (Vendôme 230) and in later copies of 1462 and 1467 at Venice and Florence.[55] In another fifteenth-century manuscript of it he is called Marius Apollinarius Cremonensis.[56] In yet another his *Recollecte* on the first book of the *Canon* of Avicenna are extant.[57]

Other treatises on the instant were composed by John of Holland, Nicole Oresme, Aquinas, Menghus Blanchellus, and Walter Burley. In the majority of cases that I have noted the form of title is *De primo et ultimo instanti*, but in the cases of Aquinas and Oresme is *De instantibus*. Once the treatise by John of Holland is called *De instanti*,[58] but its incipit,

Aristoteles octavo Physicorum ponit aliquas regulas de primo instanti et ultimo . . .

is essentially the same as

Philosophus in octavo Phisicorum ponit aliquas regulas de primo instanti et ultimo . . .[59]

which would seem favorable to *De primo et ultimo instanti* as title. Another wording, *De incipit et desinit*, was employed by Heytesbury and others. Such discussion has been carefully analyzed by Curtis Wilson,[60] who concludes:

Heytesbury's analysis of the instantaneous in motion and time goes about as far as it is possible to go by purely verbal means, and without recourse to the symbolic techniques of the calculus.[61]

Wilson does not mention a *De incipit et desinit* by Richard Lavenham of Suffolk, a Carmelite and Oxford doctor and professor who died in 1381, which is found in manuscripts at the British Museum and at St. Marks, Venice.[62] To him Tanner ascribed a *De natura instantium*, opening, "Ad cognoscendum quando est vel. . . ."[63]

In a manuscript at Milan, Ambros. G.71.sup., following Questions by Buridan on *De sensu et sensato*, at 64ra–78ra, which were copied by Bartholomeus de Castro Arquato on September 5, 1359, is the first part of *De incipit et desinit*, at 78ra–vb,

rubric, Incipit tractatus de incipit et desinit secundum Thomam Anglicum.
incipit, Ad clariorem igitur notitiam istorum terminorum duorum incipit et desinit. . . .[64]

Tanner listed several other works in physics and natural science by Richard Lavenham, and in the aforesaid manuscript at Venice there are twelve logical and six natural treatises by him. *De anima* is probably identical with a *Parvus tractatus de anima* in another manuscript which

[52] *Ibid.*, 055.

[53] Tiraqueau, André, *Commentarii de nobilitate*, Venice, 1574, cap. 31, Medicorum per alphabetum nomenclatura.

[54] *Recueil des plus celebres astrologues et quelques hommes doctes*, ed. Ernest Wickersheimer, 255, Paris, 1929.

[55] S. Marco V.32 (Valentinelli X.81), fol. 268; Riccard. L.I. xxxvi in Lami's Catalogue at p. 58.

[56] Plagens 172 Cpl (457) 13, 151 fols.: "Circa librum de anima primo queritur . . ./. . . abicientem actum. Et sic finis questionum super libro de anima secundum Marium Apollinarium Cremonensem philosophorum principem et medicorum monarcham triumphantem per me Raynerum de Fusia alemanum."

[57] Vendôme 170, 31–80, opening, "Utrum corpus humanum sanabile sit. . . ."

[58] Thorndike and Kibre, *op. cit.*, col. 58, where by a misprint VE VI.30 is given as VE VI.60.

[59] *Ibid.*, col. 488; where, however, the three mss listed are equally divided between *De instanti*, *De instantibus*, and *De primo et ultimo instanti* as the form of title. In a fourth manuscript with the same incipit, BN 16401, end of fourteenth century, 128r–149v, "Explicit tractatus de instantibus bonus et utilis." At first I thought that the incipit of Burley's treatise in VA 3026, "Utrum sit dare primum instans rei permanentis in esse . . ." might indicate a different problem or approach thereto from the "Utrum sit dare primum et ultimum. . ." of Bodleian, canon. misc. 177, anno 1399, fol. 11, but Professor Clagett has very kindly checked his film against other copies of the work and found that the contents agree throughout, and that the incipits, if prolonged, are in essential agreement. Thus "utrum sit dare primum et ultimum instans . . ." continued in VA 3066, 52v, "in quo res permanens habet esse. . . ." A manuscript of Burley's treatise in New York is, at Columbia University, Plimpton 171, anno 1396, 7ra–10ra.

[60] *Op. cit.*, chapter 2, De incipit et desinit, 29–56.

[61] *Ibid.*, 56.

[62] Sloane 3899, fourteenth century, 30r–40v, opening, "Omnis propositio affirmativa vel negativa . . ."; fondo antico 300 (Valentinelli X.207), fourteenth century, 73–78; Valentinelli gives no incipit.

[63] Tanner, Thomas, *Bibliotheca brittanico-hibernica*, London, 1748. In fondo antico 300, 63–64, what Valentinelli catalogues as *De natura operantium* may be the same work.

[64] Thomas Anglicus also is not mentioned by Wilson. In Additional MS 15107 at the British Museum, fifteenth century, 43v–45v, is a *Physonomia Thome Anglici* opening, "Diverse membrorum dispositiones secundum artem physonomie diversos affectiones et mores inducunt. . . ."

opens, "Anima est actus corporis organici . . .";[65] and *De potentiis activis et passivis*, the same as that which opens, "Cum potentia cuiuscumque rei . . ." in yet another manuscript.[66] But the incipit given by Valentinelli for its *De causis naturalibus*, "Quatuor sunt complexiones hominum . . ." differs from that usually encountered in manuscripts for such a work by him.[67]

This last work consists of sixteen questions as to meteorological matters, devoting a paragraph each to the natural causes of thunder and coruscation, the rainbow, dew, rain and hail, the saltiness of the sea, tides, springs, earthquakes and winds. Other questions are why springs are hot in winter and cold in summer, why they rarely or never freeze, why earth always remains at the center, whether clouds can be generated in the upper part of the air or in the middle region, whether vapor is the material of winds and clouds, and whether it is substance or accident, and if substance, whether a simple or mixed body.

After citations from Aristotle to prove that God and nature do nothing in vain, Lavenham says that the natural cause of thunder and coruscation is the extinction of fire in a damp cloud. Aristotle says that as a hot iron quenched in water makes a hissing noise, so hot vapor elevated from the earth and thereby inflamed touches a wet cloud and produces the noise called thunder and the burst of flame known as coruscation.

The explanation of the rainbow is brief and general, but tides are ascribed to the attraction of the ocean by the moon, although Aristotle gave another explanation. The origin of springs according to Grosseteste's commentary on the *Meteorologica* is explained by mountains being as porous as sponges and attracting water from various parts of the earth. The water becomes more subtle and purified as the attraction is greater or less, and the springs burst forth sometimes from the summit, sometimes from the middle, and sometimes from the foot of the mountain. It is not definitely stated that the water is drawn from the sea through subterranean caverns and reservoirs.

Clouds can be generated only in the mid-region of the air which is neither too hot, as the upper region is from its proximity to the movement of the heavens and the sphere of fire, and as the lower region is from refraction of the sun's rays from the earth's surface, nor yet too cold. In this connection Albertus Magnus is cited.

Cold and humid vapor supplies the material of clouds in mid-air; cold and dry vapor, that of winds; just as hot and dry vapor is the material from which are generated all phenomena in the upper air such as comets. Vapor is a substance and a simple body. If it is asked how hot and dry vapor can arise from the earth which is cold and dry, the answer is that heat is incorporated in it by the refraction of the sun's rays.

The central position of the earth in the universe is explained by Urso in his *Aphorisms*,[68] as due to the equal attraction exerted upon it from all directions by the surrounding heavens, and it is stated that a ball of lead dropped into a hole running clear through the earth would not fall beyond the center but stop there.

Returning from this digression as to tracts on the instant and Richard Lavenham, we find that VA 2225 next goes back in time at 53ra–66vb to the treatise on degrees in medicines composed by Jordanus de Turre as dean of the medical faculty of Montpellier in 1325, and then, at 71ra–83ra,[69] to the thirteenth-century *Theorica planctarum* of Campanus of Novara, written, however, in a hand of the fifteenth century. It returns to physics at 88ra-90ra with an anonymous

Utrum proportio velocitatis in motibus sit sicut proportio velocitatis potentiarum moventium ad potentias resistentes?[70]

A similarly worded question is later on ascribed to Marliani,[71] but there immediately follows, at 90ra–98vb, the Questions on Euclid by Nicole Oresme which have been discussed by Annaliese

[65] British Museum, Royal 12.B.XIX, 1r.

[66] British Museum, Sloane 3899, fourteenth century, 69v–72r.

[67] In Cambridge University Library, MS Hh.IV.13, 55r–58r, of which I have a photostat, the title is *Libellus de causis naturalibus*, and the incipit, "Deus enim et natura nihil operantur frustra . . ."; and likewise in Royal 12.E.XVI, fifteenth century, 5r–9, at the British Museum, where it is found also in Sloane 3899, fourteenth century, 59r–64. Anonymous in Corpus 132, fifteenth century, 84v–88r, at Oxford, where *enim* is omitted from the incipit; and in All Souls 81, 26r–39r, with yet a third incipit and incomplete text: see my: Uncatalogued texts in MS. All Souls College 81, Oxford, *Ambix* **7**: 34–41, 1959, especially pp. 36–37.

[68] Urso of Calabria flourished in the twelfth century. On his *Liber aphorismorum*, see the dissertation of Gebhard von Jagow, Leipzig, 1924, and the edition by R. Creutz, *Quellen und Studien d. Gesch. d. Naturwiss. u. Medizin* **5**: 10–18, 1936.

[69] Where it seems to break off unfinished, leaving 83rb–87v blank after it, as 67r–70v were blank before it.

[70] Professor Clagett has a microfilm of this: see *Manuscripta* **2**: 142, 1958.

[71] At 130vb, as mentioned above.

Maier on the basis of our manuscript and Chigi F.IV.66, 22v–40r, a more usable version.[72] VA 2225 again turns medical with two tracts by Gentile da Foligno (died 1348) on hypostasis and doses which are apparently written in the same hand as the previous work of Jordanus de Turre:

99ra–101vb, Incipit questio de ypostasi secundum excellentissimum artium et medicine doctorem magistrum Gentilem de Fulgineo. Dubitatur utrum ypostasis apparens in urina in febre putrida decidetur a materia actu putrescente vel a materia parata putrescere . . ./. . . Explicit questio de ypostasi secundum magistrum Gentilem de Fulgineo.

101vb–107rb, Incipit tractatus de dosibus secundum famosissimum artium et medicine doctorem magistrum Gentilem de Fulgineo. Gratia lucidioris habitus quem Mesue denotat in modis et proportionibus medicinarum . . ./. . . Explicit tractatus de dosibus subtilissimi artium et medicine doctoris magistri Gentilis de Fulgineo. [107va–108vb are blank.]

Then several questions by Sigismund de Polcastris on the limits of temperance, the reduction of bodies, the restoration of *humidum substantificum* (rather than *humidum radicale*), and the actuation of medicines,[73] this last composed in 1444, are intermingled with others, most of which are here anonymous. Sigismund passed his examination for the licentiate in 1422 at Padua, where he became a junior colleague to Michael Savonarola, who addressed to him his chief medical work or *Practica*.[74] In VA 2225, 130va, he is called "the monarch of medical men in this age."

It is in such distinguished company that Simon Geminius is found. Yet he is not mentioned in Vermiglioli's book on writers of Perugia[75] or in Ermini's history of the University of Perugia,[76] much less in the more general works of Zedler, Tiraboschi, Fabricius, and Chevalier. He is the most recent writer in VA 2225, his work being dated at its close, "from our houses at Perugia, April 16, 1470." Although the body of the work is a disputation in scholastic form, with much citing of authorities, of the question whether quantity is to be numbered among active and passive virtues, it is not represented as a university product or a copy made by a student of his master's argument, but is encased in a humanistic envelope in the form of an epistle to a personal friend, a Niccolò of Tivoli, to whom a preface of a few lines is couched in humanist phraseology, such as, "Tu vero qui Minerva altrice educatus es," and who in closing is addressed with the words, "Bene vale, Nicolae sapi dulcissime." This at once brought to mind the letter which Niccolò da Foligno addressed to his *compater* Niccolò in answer to the query, "Are ideas a force in natural generation?" which I published years ago from another Vatican manuscript,[77] and which was written in the same year, 1470, a few months earlier on January 10. Moreover, it was elicited by a query from Perugia, where Niccolò da Foligno once taught, and whence Simon Geminius writes. Furthermore, Niccolò da Foligno, his Nicolaus *compater*, and Simon Geminius were all interested in both medicine and philosophy. Probably Niccolò of Tivoli was, too.

The preface over, Simon takes up the question whether quantity is to be reckoned among active and passive virtues. He will argue first for the negative, then for the affirmative, and finally decide in its favor. Averroes denies it in many places in the fourth book of the *Physics*, especially in comment 84. So does Suiseth in *De potentia rei*, a section of the *Calculationes*, where he expressly denies that action is from quantity. And in treating of maximum and minimum, Suiseth denies that quantity can resist. For the affirmative, Geminius notes that the ancients regarded odd numbers as masculine and even numbers as feminine, and that physicians administer an odd rather than an even number of pills. For a time he chiefly cites ancient authorities, but also Macrobius and Isidore, Roger, Avicenna and Scotus.

Turning to the power of words, Simon argues, citing Scotus, 4 *Sent.* 13 *Dist.* 2 *Quest.*, that the sacrament will not work without them, and that all miracles are performed with them. A third proof is the words uttered by a magician in the ear of a bull, which caused the bull to fall down in the presence of St. Silvester. A fourth proof is snake-charming by words, "as most glorious Conciliator (i.e. Peter of Abano) reports." There is also virtue in time and motion and space, for Aristotle says in the fourth book *De celo et mundo*,

[72] Maier, A., *Zwei Grundprobleme der scholastischen Naturphilosophie* (2. Auflage, x, 326 pp.), 90. See also Dana Durand in *Speculum* **16**: 173, 1941.

[73] For these see Thorndike and Kibre, *op. cit.*, Index.

[74] Thorndike, Lynn, *Magic and experimental science* **4**: 186.

[75] Vermiglioli, G. B., *Biografia degli scrittori Perugini e notizie delle opere loro*, 2 vols., 1828–1829.

[76] Ermini, Giuseppe, *Storia della università di Perugia*, 762 pp., Bologna, 1947.

[77] Thorndike, Lynn, *Science and thought in the fifteenth century*, 308–331, 1929, from VA 3897, 79r–86r.

that the more space a heavy body acquires, so much the more it acquires of the form of gravity. And Jordanus *De ponderibus* says that a body moves faster, the more it acquires of the form of gravity.

After citing Lucretius, Geminius turns to Albertus Magnus. According to his *Meteorology*, book 4, tractate 1, chapter 23, there are two kinds of density: much gelidity in the digerent, and much indigestible immundity,[78] from which density comes about in lead and also weight, as his words show in chapter 3 of his fourth book on Minerals.

> For he says, The great weight of lead is from its muddy and humid substance, whose parts are in close proximity but are soft because they suffer indigestion.[79]

A third cause of density, exuberant dryness, is found in iron, which is composed of impure, terrestrial quicksilver and red sulphur cooked to a stoniness. So it is drier than all the other things that artificers extend by hammering, and cannot be melted and cast without the greatest mastery, as is shown in alchemy. Lead has less sulphur than iron and more quicksilver, and remains soft and is dissolved at once, as Roger Bacon says. *Sic ergo patet dempsitatem in ferro ex stantesi et ex molensi in plumbo.* Merchants, "perhaps instructed by Serapion" on simple medicines, keep lead in cold and wet places to make it denser, whereas smiths harden the axles of wheels, and knights, the edges of swords and points of their lances, by quenching them in a very dry liquor such as water of radishes mixed with the humor from earthworms. Aristotle's statement that hardness follows density is to be understood of things of the same denomination, which iron and lead are not. Lead is heavier than earth, which possesses only elemental weight, while lead combines elemental and compound weight.

Geminius soon cites Roger Bacon again, "in *De influentia agentis in passum*[80] prope finem." He adduces the second book of Ptolemy's *Optics* —the first book is lost—and the fourth book of Alhazen on aspects for the assertion that "quantity produces quantity, just as heat produces heat," and the fourth book of Witelo's *Perspective*, theorem 63. He rebuts the argument of Suiseth, "lord Calculator in his treatise on reaction,"[81] that, if quantity is active, fire would be of ponderable(?)[82] quantity.

Geminius holds that the mode of intension in quantity differs from that in quality. Intension in quality, according to the prevailing opinion, is by addition of quality to quality in the same subject, while intension of quantity is made by placing quantity next to quantity. Perhaps it may similarly be said that the mode of intension of accidents which are immediately founded in undetermined dimensions differs from that which derives from qualities fixed in quantity of definite dimensions.[83]

The most recent authority cited by Geminius is Paul of Venice, who died in 1429, and to whose argument against Walter Burley as to the proper exposition of Averroes' 63rd comment on the *Metaphysics* Geminius replies.[84] His next most recent authority is Marsilius de Inghen, "primo de generatione, questione 16, articulo primo."[85] Marsilius died in 1396 and the work cited was written shortly before 1385. In closing Geminius raises another question, Whether rarity and density are positive or negative.

Despite its humanistic epistolary envelope and its citation for a time of classical authors, it seems evident that the treatise by Simon Geminius, physician and philosopher, is not inappropriately

[78] This is Geminius's interpretation of Albertus rather than what is actually said by the latter, who in the chapter cited is discussing the Aristotelian *molinsis*, or half-boiled state, and does not use the word *densitas*.

[79] This quotation is more exact. See *B. Alberti Magni . . . opera omnia*, ed. Borgnet, A., Paris, **5**: 87a, 1890: "Multum autem pondus plumbi est ex lutea substantia ipsius et humida, cuius partes sunt multum propinquae, licet sint molles, eo quod indigestionem passae sunt ex molinsi, sicut superius determinatum est."

[80] I know of no separate work by Roger Bacon with precisely that title. Perhaps a section of his *De multiplicatione specierum* or *Opus maius* is meant. In *Opus tertium* (ed. J. S. Brewer, 99, 1859) Roger refers to a "Tractatum de speciebus et virtutibus agentium."

[81] The section of the *Calculationes* of Richard Suiseth or Swineshead which precedes *De potentia rei* is entitled *De reactione*.

[82] VA 2225, fol. 6ra: "detur ergo ignis pedalis (or, pod alis) quantitatis." Maigne d'Arnis, *Lexicon manuale ad scriptores mediae et infimae latinitatis*, defines *pedalis* as "Genus mensurae lignariae; "mesure pour le bois . . ."

[83] VA 2225, fol. 6vb: "Ex quibus colligitur quod alius est modus intensionis in quantitate ab illo quod est in qualitate. Intensio enim in qualitate secundum communiorem sententiam fit per additionem qualitatis ad qualitatem in eodem subiecto. Intensio autem quantitatis non, sed per positionem quantitatis iuxta quantitatem. . . .

"Et consimiliter forsan dici posset quod alius est modus intensionis accidentium que immediate fundantur in dimensionibus interminatis ab illo qui debetur (7ra) qualitatibus fundatis in quantitate mediantibus dimensionibus terminatis."

[84] *Ibid.*, fol. 7rb.

[85] *Ibid.*, fol. 8rb.

found in the same manuscript with those works on physics and medicine of the thirteenth, fourteenth, and early fifteenth centuries which we have listed earlier, and that he shared their interests, although writing from Perugia in 1470.

NAPLES V.H.190

The contents of this manuscript are roughly contemporary with Geminius and are largely physical. Some Conclusions concerning motion, human generation, etc. from Florence on June 22, 1474,[86] include nose and pug-nose,[87] but open with the conclusion,

Non omnis transmutationis naturalis secundum philosophos principia sunt contraria

and corollary,

Non omne quod movetur movetur ex aliquo in aliquid tamquam ex termino a quo in terminum ad quem.

Subsequent discussion whether the generation of substance is true motion according to the description of motion given in the text of book III of the *Physics*, comment 6, and book VIII, comment 4, is dated on Friday, May 20, 1474:

Vale igitur decus meum. Et si quando dominus dabit dubia nonnulla alia physicalia post Veneris diem hanc XXam Mai anno a nativitate Iesu M.CCCC.74, uti pollicit fuimus, adducemus.[88]

Here again we note the combination of humanistic epistolary form with scholastic content. The remainder of the manuscript, however, consists mainly of notes taken or texts copied by students at Pisa, to which the university had reverted after failing to flourish at humanistic Florence.[89]

Next is argued the stock question whether a mobile body should be regarded as the subject of the *Physics*.[90] After some blank pages,[91] a text in a different hand opens with an illuminated initial letter at fol. 19ra, "Aristoteles determinaturus de rebus naturalibus . . ." which we recognize as the opening words of Walter Burley's *Expositio* on the *Physics*.[92] It is accompanied by a marginal gloss. At fol. 31ra, Burley in turn becomes the object of commentary, opening, "Ex dictis Burlei quatuor dicta elicio declaranda. . . ."

The title, "Pulcre rationes quod spera non possit tangere planum," in the top margin of fol. 36va, applies only to a brief text opening, "Advertendum quod corpus spericum non possit tangere planum . . .," which is followed in the same column by another, "Whether quantity is to be distinguished from substance?" Another marginal heading at fol. 38va describes the text as "Contra Albertum de Sa (xonia) et alios nonnullos Terministas." On fol. 55vb, the desinit, ". . . posse illam habere et perfici per illam si haberet," is followed by the words, FINIS PRIMI, and the further statement:

Et sic perficiuntur Reportationes primi libri Physicorum quas ego Antonius filiolus Sulmonensis 4° anno mei studii incredibili labore excepi ex dignissimo dyalethico et philosopho disceptationumque fulmine fratre Albo preceptore meo cuius dentatas ac ferratas vires qui negant sepe apothyticis syllabis reperiuntur.

Book two opens on fol. 56ra

Eorum que sunt alia quidem sunt nature alia vero propter alias causas. In exordio huius secundi libri . . .

but is unaccompanied by marginal glosses or notes and breaks off unfinished at fol. 65vb.

After a blank leaf, Book three opens on fol. 67ra:

QUONIAM AUTEM NATURA EST PRINCIPIUM motus et mutationis. Dubitatur utrum ignorato motu necesse sit ignorare naturam. Advertendum quod hic titulus istius dubitationis Burlei possit intelligi in sensu diviso. . . .

Marginal glosses and references to text and commentary accompany them to fol. 76rb. Marginal glosses resume at fols. 77rb–78vb, but not the references to text and commentary. After the closing words, ". . . per locum et coniugatis," on fol. 80vb ensues the statement:

Et sic perficiuntur Reportationes super tractatum de motu 3. Physicorum quas ego Antonius filiolus Sulmonensis in formam redegi Repcepique ex divino dyalethico et philosopho in nostrisque certaminibus . . . M.CCCC.74 die vero VIa Iulii ac anno quarto mei studii Pisis.

[86] Fol. 7vb: "Ex Florentia 1474 die XXIIe Iunii Pisis"; this last word perhaps indicates use of the Pisan calendar.

[87] Fol. 5ra: "Naturaliter loquendo symitas potest esse absque naso."

[88] Fol. 12ra.

[89] The University of Florence was abolished in 1472 by Lorenzo de' Medici and restored to Pisa.

[90] Fols. 13ra–15ra: "Queritur utrum corpus mobile debeat poni subiectum libri physicorum. . . ." This may be the same text as a "Questio de subiecto scientie maturalis," in MS Erfurt, Amplon. F.346, early fourteenth century, fol. 67r–69, but Schum's catalogue gives only "Utrum corpus mobile . . ." of its incipit. At fol. 14r of our MS is a marginal gloss.

[91] Most of fol. 15 is blank; 16 and 17 are missing; 18 is blank.

[92] It was first printed in 1476.

Two pieces of text, anonymous in our manuscript, may be catalogued as follows:

81ra–87ra: SIMILITER AUTEM NECESSE EST PHYSICUM. Motus localis est communior aliis motibus. Hoc vero intelligitur secundum predicamen de ipsis aliis motibus . . . . . in omni loco sit corpus non tamen omne corpus est in loco.

87rb–va: Notandum quod diffinitio temporis data a philosopho 4° Physicorum . . .

The rest of fol. 87 is blank, as are fols. 88–89, while on the next leaf, numbered 99, begins a discussion of a Question of William of Hentisbery.

99ra: SCIRE MULTIS MODIS DICITUR. Sed sive communiter sive proprie sumatur, nihil scitur ab aliquo quod eidem est dubium. Circa intellectum huius questionis varii sunt opiniones.
Prima est Gaietani
2a est opinio volens . . .
3a opinio est Petri Mantuani
100va: . . . pro vero intellectu questionis Hentisberi.

There are marginal glosses through 101r; 103–104 are omitted; on 105rb the discussion ends; there is no fol. 106.

In the remainder of the manuscript the following items seemed of physical or chronological interest:

109r: Utrum aliqua substantia creata ab aliquo agente sit eterna . . .; ending at 113ra or 114rb.

115r: ANNO INCARNATIONIS DIVI IESU 1473 DIE VERO 13 OCTOBRIS AC HISTRI STUDII ANNO QUARTO ADVENANTE HORA VERO 23 PER (?) MELIONEM FILIOLUM PISAS INTROEUNTEM ERAT CONSPICERE QUO ANNO PISANUM STUDIUM FLORENS HABET INITIUM.
NOTA QUOD OPINIO iudicio meo recte sententium est quantitatem esse idem realiter quam substantia.

116vb (after listing six conclusions): Suprascriptas conclusiones ego Antonius filiolus Sulmonensis substinui Pisis anno 1473 die vero XV mensis Novembris, anno vero quarto mei studii Ias (?) incepto ac anno primo florentissimi studii Pisani.

HAEMOGREGARINA AURORAE N. SP. FROM *RANA A. AURORA*[1]

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DURING the summers of 1958 and 1959, a haemogregarine was found parasitizing the blood of eight of fourteen Northern Red-legged Frogs, *Rana a. aurora* collected in Marion and Benton Counties, Oregon. The parasite was determined to be different from the other described species of blood inhabiting Sporozoa of the Anura and it has been named *Haemogregarina aurorae*. Appreciation is expressed for the aid of Patrick and Kenneth Kleczynski who helped in the collection of the hosts.

Although several intra-erythrocytic sporozoans ("Haemogregarines") have been reported from North American Salientia, it is the opinion of the writer (1959) that only two genera, *Haemogregarina* and *Karyolysus*, can correctly be termed "Haemogregarines"; the following list of reported parasites is therefore abridged to include, generally, only those genera.

Langmann (1899) found the first haemogregarines from North American Salientia in "many frogs" and Stebbins (1904) described *Haemogregarina catesbianae* from *Rana catesbeiana* and in 1905 he named *Hg.* (*Karyolysus*) *clamatae* from *R. clamitans* and *R. pipiens*. Kudo (1922) also found haemogregarines in the blood of *R. pipiens* and *R. clamitans* and Sanders (1928) mentions finding *Karyolysus* in *R. clamitans*. Brandt (1936) noted *Karyolysus* or *Lankesterella* in *R. catesbeiana* and *R. sphenocephala* while Fantham *et al.* (1942) reported haemogregarines in *R. pipiens*, *R. catesbeiana* and *Bufo americanus*. Fowler (1946) found haemogregarines in grass frogs and Bailey (1948) mentions a haemogregarine from *R. pipiens*. Finally, Lehmann (1959) described *Hg. boyli* from *Rana boyli*.

MATERIALS AND METHODS

Peripheral and heart blood films were stained with Giemsa's stain. Tissue impressions of the liver, spleen, lungs, and kidney were stained with (1) Giemsa's stain, following fixation in absolute methanol, and (2) Heidenhain's iron haematoxylin after fixing in Schaudinn's fluid. Sections of the viscera, 10 microns in thickness, were also stained with haematoxylin. The following description is based upon data from Giemsa's and haematoxylin stained films, impressions, and sections of all of the infected hosts.

HAEMOGREGARINA AURORAE N. SP.

Diagnosis.—A haemogregarine with gametocytes and trophozoites being found in erythrocytes of the peripheral blood. Schizogony, which occurs in the erythrocytes and erythroblasts of the liver, typically yields four sausage shaped merozoites. Leucocytes are not infected.

Host.—*Rana a. aurora.*

Location.—Circulatory system.

Locality.—Benton and Marion counties, Oregon.

PARASITES OF THE PERIPHERAL BLOOD

Two types of parasites were found in the peripheral blood: trophozoites and gametocytes. The intraerythrocytic trophozoites (fig. 1) did not appear to be contained within a capsule; they were 11.7 (9.5–14.0) microns in length by 4.4 (3.8–7.1) microns in width. The large irregular nucleus, which was not surrounded by a visible membrane, extended over about one-half of the central area of the parasite. The cytoplasm was homogeneous except for the presence of one to four vacuoles of variable size at each extremity. The position of the parasite was not consistent but the nucleus of the host cell was generally pushed away from its normal position; the host cell was otherwise unchanged.

Gametocytes were found either within greatly distorted erythrocytes (fig. 2) or lying free in the plasma (fig. 3); in the latter instance, each body was enclosed within a well-defined capsule. Each gametocyte, regardless of location, possessed a club-like form, one end being broader than the other. Intraerythrocytic gametocytes were often distorted owing to the molding effect of the enclosing erythrocyte, the resultant body having a fishhook-like appearance (fig. 4). The length of the gametocytes was 17.9 (15.1–24.5)

[1] This investigation was supported by a grant from the Johnson Fund of the American Philosophical Society.

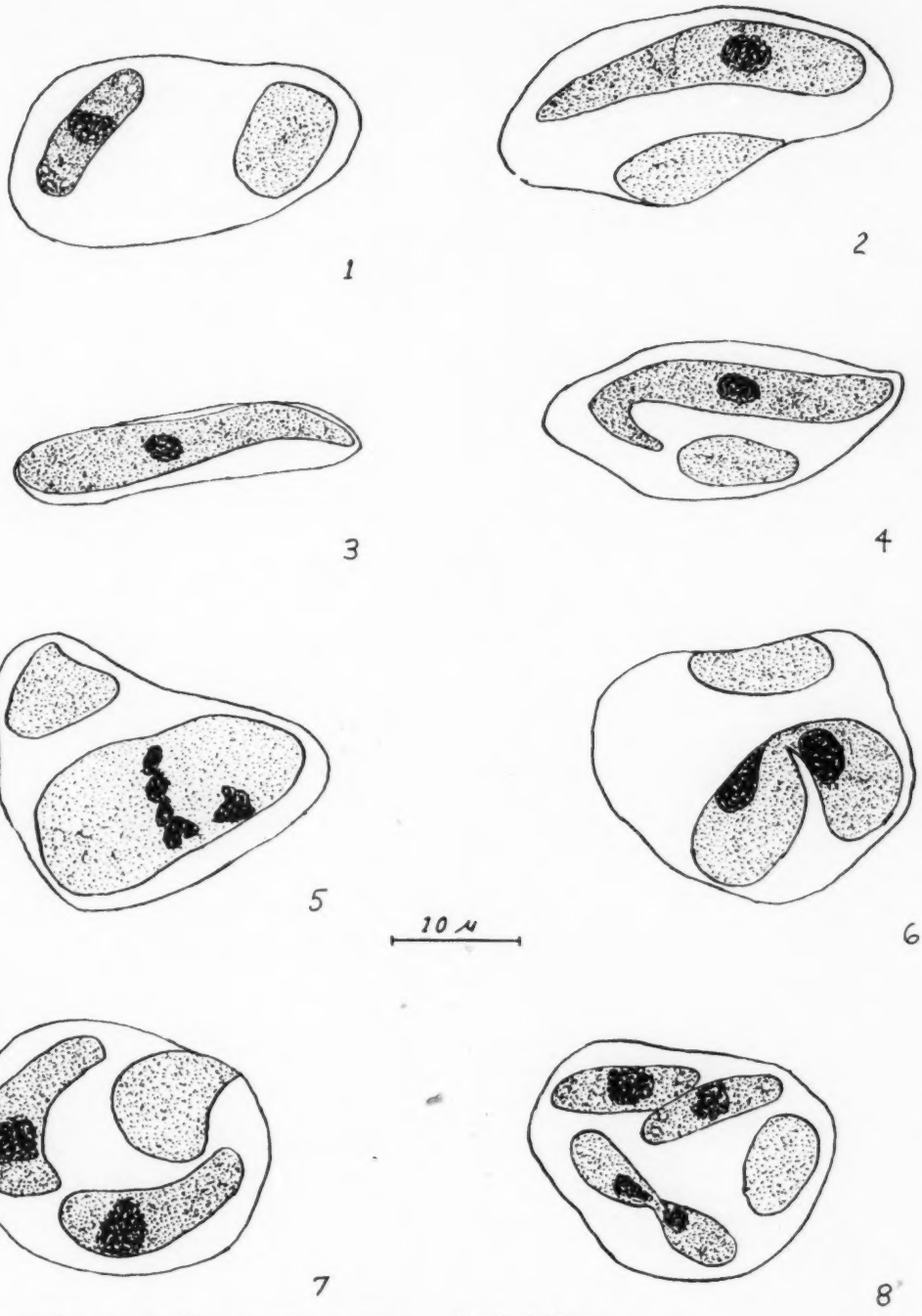

FIG. 1. Erythrocyte containing recently penetrated trophozoite.
FIG. 2. Gametocyte in erythrocyte.
FIG. 3. Gametocyte in plasma.
FIG. 4. Intraerythrocytic gametocyte distorted by molding of the host cell.
FIG. 5. Schizont.
FIG. 6. Dividing schizont.
FIG. 7. Bodies resulting from first schizogonic division.
FIG. 8. Four merozoites resulting from schizogony.

microns and the width, at the widest end, was 5.2 (4.8–7.0) microns. The nucleus was central and discreet but not surrounded by a membrane. The cytoplasm was homogeneous, no vacuoles having been seen.

PARASITES OF THE VISCERA

With the exception of the liver, the viscera contained forms similar to those found in the peripheral blood. Impressions, smears and sections of the liver revealed the presence of stages that were found in no other location.

Trophozoites found in the erythrocytes and erythroblasts of the liver were morphologically similar to those found in the peripheral blood; schizonts (fig. 5), which developed from the trophozoites, averaged 18.8 (14.1–21.0) microns in length by 9.2 (8.9–10.3) microns in width. These forms often possessed paired nuclei and a cytoplasmic constriction (fig. 6). The first division produced two secondary bodies (fig. 7) measuring 16.1 (13.0–20.2) microns in length by 5.9 (5.2–7.7) microns in width; division of each of the secondary bodies (fig. 8) resulted in the formation of the typical four merozoites measuring 11.2 (8.1–17.0) microns in length by 3.9 (2.5–6.0) microns in width. The merozoites, which were released from the erythrocyte or erythroblast were of similar dimensions and appearance to the recently penetrated forms described from peripheral and liver blood.

Gametocytes, similar to those described from the peripheral blood were also found in the erythrocytes of the liver. In addition, intermediate and small gametocytes were also found within the erythrocytes of the liver. It was not possible, however, to determine the type of merozoite that gave rise to the gametocytes.

DISCUSSION

The vertebrate cycles of only three species of haemogregarines from the Ranidae have been determined (at least in part). *Haemogregarina* (*Karyolysus*) *clamatae* (Stebbins, 1905) and *Hg. catesbianae* Stebbins, 1904, are described and figured as producing large numbers of small merozoites, far in excess of the four typically formed by *Hg. aurorae*. *Hg. boyli* Lehmann, 1959, yields only two merozoites upon division of the schizont which, like *Hg. aurorae*, is contained within the erythroblasts and erythrocytes of the liver. This number, of course, is only half that found in *Hg. aurorae*. If the species of the haemogregarines of the Amphibia may be distinguished on the basis of numbers of merozoites produced, and this appears likely, then *Hg. aurorae* is a valid species.

SUMMARY

Haemogregarina aurorae n. sp. is described from the Northern Red-legged Frog, *Rana a. aurora*. Gametocytes and trophozoites are found in the erythrocytes of the peripheral blood, spleen, lungs, and kindneys. Schizogony, which occurs in the erythrocytes and erythroblasts of the liver, results in the production of four merozoites of similar dimensions.

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THE SCIENTIFIC WORK OF NATHANIEL LORD BRITTON

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BRITTON'S career as a botanist, beginning as an undergraduate student and continuing until the last year of his life, is characterized by adherence to several well-defined principles. No one can now say whether Britton ever formulated or chose these principles as a guide to his actions, but many of his remarks and much of his advice to others during his later years indicate that he eventually understood them and followed them deliberately. Among them may be distinguished the careful planning of every proposed action in advance, the immediate translation of thought into deeds, the completion of each project with the least possible delay. The reputation which he won is shown by his election in 1903, by the formal and independent vote of leading American botanists, as the second botanist in rank in the United States, preceded only by a man fifteen years his senior and followed in order by four men respectively eight, two, fourteen, and six years his senior.

While all these habits of thought and action appear repeatedly in Britton's career, one of them is so important that it deserves special consideration. Britton fully appreciated the well-known facts that all scientific work becomes out of date as soon as published and that every line of investigation may be pursued indefinitely without exhausting it. But he also understood the law of diminishing returns, and knew that the results of any research which is of real scientific value should be made available to other students promptly, so that they, with different points of view, different lines of attack, and different facilities, may proceed further independently. Therefore, he did not hesitate to publish his *Flora of Puerto Rico*, for example, at a time when the results of his work were sufficiently complete to be of service to others, without waiting for the discovery of other facts which he later incorporated into an extensive appendix. At the present time, some twenty years later, a second appendix could be written; yet it is certain that most of the discoveries which it might contain would never have been made if the original volumes had not been published. Too often the modern scientist prolongs his study unduly in the vain hope that he will eventually complete it absolutely, and in so doing he merely hampers or delays equally valuable work by others. Britton's motto, on the contrary, frequently heard by his colleagues at the New York Botanical Garden, was "Get it into print," and his personal adherence to the principle made his work especially valuable.

Britton's was not a one-track mind. He could and habitually did attend to the multifarious duties of administration while also carrying on several lines of botanical investigation. His botanical work is accordingly discussed in the following pages by subject rather than chronologically.

EARLY BOTANICAL ACTIVITIES

Britton obviously became interested in botany at an early age. He was only eighteen when elected to membership in the Torrey Botanical Club and his first printed contribution appeared the same year. As a matter of convenience, his early period may be considered as extending to his retirement as Professor of Botany in Columbia College at the early age of thirty-seven.

For a few years, until he reached the age of twenty-three, his whole botanical experience was apparently limited to the general vicinity of New York City, and the numerous short articles published by him were equally restricted in their scope. The only one which demonstrated any taxonomic perspicuity was a short note on the difference between two species of *Cyperus*. Similar short articles, representing what may be termed merely interesting observations, continued until about 1886, after which they rapidly decreased and eventually ceased, probably in response to his greater engagement in actual research and the more confining duties of a college professorship.

Gradually his interest extended beyond the local flora. In 1880 he mentioned a plant from as far away as Norfolk, Virginia; in 1882 he visited the Rocky Mountains; in 1883 he traveled in the upper Peninsula of Michigan; in 1884 he studied and reported on a small collection of

plants from Alaska and another from Texas and New Mexico. His first new species of plant was described in 1884: *Cyperus rusbyi*, from New Mexico; a second new *Cyperus* was proposed in 1885. He published a condensed revision of the genus *Scleria* in 1885 and a long list of the North American species of *Cyperus* in 1886. The following year appeared a short but carefully prepared paper on *Cerastium arvense* and its varieties, in collaboration with his close friend, Charles Arthur Hollick.

During the early eighties he was employed as botanist and assistant geologist by the Geological Survey of New Jersey. His botanical observations during the period resulted in a number of short notes on the plants of the state and in two much longer compilations. The first, a preliminary catalogue of the plants of New Jersey, appeared in 1881, and his final report on the same subject, with more than six hundred pages, was ready for distribution in 1890, several years after he had left the Geological Survey. It is probable that the work was actually completed in the herbarium at Columbia College.

As early as 1879, when Britton was only twenty years old, he announced in the *Bulletin* of the Torrey Club that he was undertaking a study of the genus *Cyperus* and solicited specimens "from all quarters." This early interest soon broadened to include the family Cyperaceae as a whole, except the genus *Carex*, to which he never gave much attention. His work on the Cyperaceae was zealously prosecuted, even in the years when he was employed by the New Jersey Geological Survey, since the four papers on the subject already mentioned and another brief list of species were published during this period. It can scarcely be supposed that this work was sponsored by the Geological Survey: it must have been done on Sundays and holidays and is the first indication of the remarkable energy which drove him into continuous work during the remainder of his life. Five other papers on the Cyperaceae appeared during the next ten years, in addition to his treatment of the family in the *Illustrated Flora*, but none of them was of particular significance.

As early as 1879 Britton and Hollick published their *Flora of Staten Island*, a modest work of thirty-six pages. Britton was then only twenty, and all the basic work preliminary to publication was done during his teens. Neither he nor Hollick ever lost interest in their home borough. The catalogue was kept up to date by a series of supplements, begun in 1880 and continued at irregular intervals until 1895, while various other short articles on the plant life of the island were also published by Britton from time to time.

Britton's collegiate education was in geology more than in botany. This, and his experience with the New Jersey Geological Survey led to various bits of observation and research along geological lines. Thirty-six such articles represent the results of his studies during the eighties; after this decade his interests were almost wholly botanical, although two short papers dealing with fossil plants appeared in 1893 and 1898.

Upon his appointment to the faculty at Columbia College, Britton at once undertook the reorganization of the botanical collections, which had been largely neglected since the death of Professor John Torrey in 1873. Much unidentified material had been received during these two decades and Britton's first task was to get these specimens properly named. In doing so he found much of scientific interest; extensions of known geographical distribution, undescribed plants, new evidence on the classification and concept of species. He issued a short article in 1887, describing the collections at the Columbia herbarium, and then plunged into the task of classifying and arranging them. His scientific results were published in a series of papers, nearly thirty in number, during the next ten years. About half of these were collections of scattered notes on various species; the other half included more extended observations on the classification of species within certain genera. Some of these papers were developed in connection with his preparation of the *Illustrated Flora* and referred to problems which required discussion to an extent scarcely appropriate in the more formal treatment of the finished work.

During this period at Columbia College, Britton first became interested in the flora of tropical America. Henry Hurd Rusby had made extensive collections in Bolivia in 1885 and 1886, and these were turned over to Britton for study, either wholly or in part. He must have found much difficulty in his efforts to identify them. South American plants for comparison were few; literature on Bolivian plants was widely scattered and not always available in the New York libraries; most of the genera and even some of the families must have been unfamiliar to the young botanist of thirty years. Naturally he made many errors. His first published report was on a supposed new genus, not long since relegated to

synonymy. After this came a series of short articles, twenty in all, usually of four to eight pages each, which continued at irregular intervals from 1889 to 1893. In them he described eighty-seven new species and listed hundreds of others. For some groups he turned to European specialists for aid: the Polygalaceae were named by A. W. Bennett, of England, and the Melastomataceae by Alfred Cogniaux, of Belgium.

The bibliography of Britton's published work, as compiled by John Hendley Barnhart, shows no less than 304 titles for the period of twenty-one years, 1877 to 1897, inclusive. This is certainly an impressive figure. Examination of the titles or the originals indicates that many of them were reviews, many others short notes or observations or printed statements of oral remarks in scientific meetings, and still others discussions of questions of nomenclature. Two of his larger works, dealing with the flora of New Jersey, were largely compilations, although naturally requiring much study and critical judgment by the author. The actual taxonomic research is distinctly limited in quantity and by no means impressive in quality. Not one article shows the painstaking care or the originality of thought which Britton himself would have demanded from a student in a doctoral thesis. There is nothing in any of them to indicate that Britton was the equal of Gray, Watson, Trelease, Vasey, or other leading taxonomists of the day, or even to suggest that he would ultimately develop into a leader in his field. His chief claim to botanical prominence by the end of this early period arose from the dignity of his position as Professor of Botany in Columbia College, his activity as a valiant warrior in the battle of nomenclature, and the remarkable, in fact unexpected, production of the great *Illustrated Flora*. These last two items call for special discussion, presented in succeeding parts of this article. As the years had passed he had accumulated a great store of knowledge of the flora of the western hemisphere and his powers as an organizer and administrator had been developed.

BOTANICAL ORGANIZATIONS

Britton had not yet graduated from Columbia College when he began to associate with botanists and to participate actively in botanical affairs. He was elected to membership in the Torrey Club in 1877, at the age of eighteen, and for years thereafter he was present at and took some part in almost every meeting. His participation included the presentation of formal papers and critical discussion of those read by others, but he was especially interested in exhibiting and commenting upon some interesting single plant which he brought to the meeting with him. Among these were the fruit of the chocolate tree, a plant of mistletoe collected in New Jersey, a dogwood flower with double bracts, a plant of trefoil with leaves of unusual shape. All of these, trivial though they may now seem, must have been of interest to the amateur botanists of the Club and must have helped to enliven the meetings. He also often brought a set of dried specimens and distributed them to the members present for their own private herbaria.

He became Librarian of the Club in 1882 and held the office for seven years. He was then elected to the more important post of Editor of the *Bulletin* of the Torrey Botanical Club and served in that capacity for nine years.

As his responsibilities grew, his visible activity in the affairs of the Club decreased, but he was continuously a power behind the throne in all the more important problems with which the Club was faced. The charter of the New York Botanical Garden provided that the President of the Torrey Botanical Club should be a member of the Scientific Directors. It was distinctly to Britton's interest to see that the President was a suitable member of the Directors as well, not only interested in the welfare of the Club but also in full accord with Britton's policies at the Garden. Through the entire period of his active connection with the Garden, he was consulted before the nomination and election of the Club's President. Such a statement of fact can carry no possible implication concerning his motives or the results. The mere list of the presidents of the Club during this period, Henry H. Rusby, Edward S. Burgess, Robert A. Harper, Herbert M. Richards, and Herbert M. Denslow, is sufficient to indicate their character and ability.

Shortly after graduation from Columbia College, Britton began to attend the regular annual meetings of the American Association for the Advancement of Science. For many years the botanists kept a register of the attendants, and this old book, now deposited at the New York Botanical Garden, indicates that he was present at eighteen of these meetings between 1884 and 1906, missing not more than five. The minutes and the printed reports show that he presented papers, took part in discussion, or served as an officer or on committees at many of the sessions. After 1906 his

activity was much reduced, largely because of the necessity of preparing for the annual meeting of his Board of Managers, held in January, and of arranging for his annual winter vacation in the West Indies.

The printed report of the Ann Arbor meeting of the Association in 1885 contains an interesting item:

> The club received the announcement that two of its former members, Dr. N. L. Britton and Miss Elizabeth G. Knight, both of New York City, had matrimonially united their fortunes on the preceding day, which accounted for their absence from the present meeting. The hearty congratulations of the club were forwarded to them by telegram.

The inception of the Botanical Society of America dates back to 1892 and organization was effected in the summer of 1893. It was intended that its charter members should represent the leaders of botanical thought and action in the United States. The botanists in attendance at the Madison meeting of the American Association were privileged to nominate botanists for this honor, the ten receiving the highest number of votes to constitute the nucleus of the charter membership and themselves to choose fifteen others. Britton was chosen among the first ten, a remarkable honor for a man only thirty-four years old. The following year he was elected Vice-president of the new society and four years later served as its President. His presidential address on progress in the development of the New York Botanical Garden was delivered at the Columbus meeting the following year.

The Society amalgamated with the Society for Plant Morphology and Physiology and the American Mycological Society in 1905. The united society, retaining the name Botanical Society of America, chose Britton for its first Vice-president. In 1920 he was elected President.

During the last twenty years of his life, his interest in attending the annual meetings of the Society and of the American Association for the Advancement of Science, always held simultaneously, steadily waned. He was even absent from the Chicago meeting of 1920, when he was President, although he sent a personal representative (H. A. Gleason) at his own expense. The following year he was to deliver his presidential address, the title of which had been announced as "A communication from the retiring president." Again he failed to attend, but Marshall A. Howe read his communication. This was merely a brief letter in which he transmitted to the Botanical Society his check for one thousand dollars as an addition to its permanent funds.

He was until his death an active and influential member of the New York Academy of Science, in which he was especially interested in the organization and maintenance of the Scientific Survey of Puerto Rico and the Virgin Islands. He was similarly interested in the Horticultural Society of New York, serving for many years on its board of directors, and in the Bronx Society of Art, Science and History.

THE NOMENCLATURE PROBLEM

The controversial storm over questions of nomenclature which developed among American botanists in the last decade of the nineteenth century raged for some twenty years and with decreasing violence thereafter until 1930. Its results were far-reaching and often regrettable. Botanists broke their friendships; institutions became estranged; reputations suffered. American taxonomists were divided into two parties as distinct as Democratic and Republican in national politics. As in politics, many of them had no real knowledge of the questions involved but merely accepted the opinion of some leader. Also as in politics, each party believed that the adoption of its views was the best method for attaining the ends which both sides desired. In this controversy Britton was at first a leader; later his place was ably taken by several self-appointed lieutenants. Here, as in most other affairs, he followed his usual policy of expressing his beliefs by deeds, after which his participation in the disputes was unnecessary.

It is unfortunate that such a controversy should have arisen, but it was probably unavoidable. It is still more unfortunate that the underlying causes of the controversy should have existed, but they were certainly unavoidable.

All known kinds of plants have names. Common names arise among the laity and may become an integral part of the language, but of course vary with the language from one country to another. Even in the same country and in the same language, the common or useful plants often have a multiplicity of names. Scientific names, on the contrary, are intended for international use and also express something of the classification and relationship of the plants to which they are attached. It is obvious that clarity and accuracy in the application of names demand that each should be applied to a single kind of plant, in order to avoid ambiguity in their connotation,

while common sense indicates and convenience insists that each kind of plant should have one and only one accepted name. One name for a plant, one plant for a name: these are ideals of nomenclature appreciated by all botanists.

If these ideals could be realized, nomenclature would offer no difficulties, but in actual practice it has often happened that the same names (*homonyms*) have been used for quite different kinds of plants and in thousands of instances the same plant has received two or more names (*synonyms*). It has very rarely happened that botanists have wilfully given a second name to a plant or used an existing name for a second plant. Most violations of the general principle have been due to ignorance of the work of others or to honest differences of opinion concerning classification. The problem of the botanist is to ascertain, first, for which kind of plant a homonym may properly be used; and second, which of the synonyms may be properly selected as the valid name for the plant. Having solved these problems for himself, he then faces the still more difficult task of inducing other botanists to accept his solution.

Our modern binomial system [1] of nomenclature came into general use during the latter half of the eighteenth century, chiefly through the example and influence of the Swedish naturalist Linnaeus. By the middle of the nineteenth century great numbers of synonyms and homonyms were in circulation. Alphonse de Candolle estimated that in 1845, for every hundred valid species of flowering plants, two hundred and two names were in existence, about two for the average species. In selecting one of these two names for use, the botanist of the time had no rules for a guide. A study of the botanical works of that period shows that, in general, botanists used the older of the two names and, in transferring a species from one genus to another, used its original specific name. Exceptions were numerous, however, and may be attributed sometimes to a simple desire to change, sometimes to ignorance of the work of others, and more often to a spirit of provincialism or pseudo-patriotism.

The first codification of rules of nomenclature was prepared by the eminent Swiss botanist, Alphonse de Candolle, and adopted by the International Botanical Congress of Paris in 1867. It has since been known as the Paris Code.

It is at present impossible to ascertain why or when Britton developed his interest in nomenclature, but it probably arose in connection with his work on the local flora of the New York area. The preparation of a list of the local plants had been delegated by the Torrey Botanical Club to a committee of six, composed of Justus F. Poggenburg, N. L. Britton, Addison Brown, Arthur Hollick, T. C. Porter, and E. E. Sterns. Britton, Sterns, and Poggenburg were appointed as a subcommittee to consider the nomenclature, and this committee made a special report in the introduction to the "Preliminary Catalogue," published in 1888. While this report is not signed and ostensibly represents the views of all three members, it is fair to assume that it was largely inspired by the views of Britton himself, since he was the only member with actual experience in taxonomic research.

> In the preparation of this Catalogue, [the report says] a special effort has been made to maintain for each plant as far as possible its earliest specific or varietal name. . . . Transfers from genus to genus and alterations in rank as regards species or variety, must not (except as to gender) in any wise affect the trivial name, which is held to be absolutely fixed by the first publication, so that even the author is not at liberty thereafter to modify it in any way.

Following this method of procedure, the local committee adopted a considerable number of new names for local plants, each consisting of the oldest specific epithet which they had found united with the proper generic name. Many of these have since come into general use and are distinguished by the now familiar abbreviation BSP, the initials of Britton, Sterns, and Poggenburg.

The publication of the Catalogue naturally provoked criticism and at the same time was applauded by various American botanists. It is now impossible to judge from the evidence in print to what extent botanists approved or disapproved the principles which the committee had laid down or the results of putting these principles into effect. It is noteworthy that Sudworth, one of Britton's protagonists, said in 1891 "Nearly all botanists are thoroughly in unison with the present vigorous movement to place botanical nomenclature on a firm footing."

Criticisms were of course numerous. A study of them from the distance of half a century leads

[1] In the binomial system each kind of plant (and animal) bears a name composed of two epithets, of which the first, or generic name, is borne in common by all species of a genus. The second, or specific epithet, is in itself not a name, since it does not distinguish any plant unless coupled with the name of a genus, except in some instances when two substantives in apposition make up the binomial.

one to the general opinion that they were based less on the underlying motives, as stated by the committee, or the inevitable change of names which the motives produced as on the disruption of current usage. Among the critics the chief was the English botanist James Britton. To several critics and especially to his English adversary Britton made forcible reply in print, and it is often apparent that he evinced a more thorough knowledge of the fine points involved than was possessed by his critics. His answers also showed his thorough command of the English language in written debate; they were always trenchant, to the point, and mercilessly logical.

Suggestions from his friends and objections from his foes nevertheless conspired to alter some of Britton's ideas, while strengthening his firm belief in the essential nature of others. Thus we find that he accepted tautonyms[2] in 1891, while rejecting then in 1892. He would omit the citation of the author after the parenthesis in 1891, writing for example, *Picea canadensis* (Mill.), while adding it in 1892 and writing *Picea canadensis* (Mill.) BSP. He clung tenaciously to the principle of the fixed maintenance of the original specific name. In 1891 he emphasized the cliché, "Once a synonym always a synonym," and the stubborn misunderstanding of this phrase by his opponents was later to be one of the chief difficulties in securing general acceptance of his ideas. In 1890 he wrote, "It is perfectly clear that as long as we allow ourselves a choice of names in any way, so long will authors differ in their acceptance and the settling of this important matter be delayed." This statement shows his fixed belief in the necessity of rigidity and precision in the rules of nomenclature.

The forty-first meeting of the American Association for the Advancement of Science was held at Rochester, August 18–24, 1892. As usual, the botanists met together under the name of the Botanical Club, with H. H. Rusby in the chair. On the morning of the first day, as we read in the official minutes, under the head of new business, Dr. N. L. Britton presented the following resolution, the outcome of a preliminary meeting of those especially interested in questions of nomenclature, held the night previous:

> In view of the great desirability of establishing a stable system of botanical nomenclature in North America, I move the appointment of a committee of seven members of the Club, of which the President shall be one, to consider the questions involved, and to submit a set of recommendations to the Club before the close of the present session.
>
> The resolution was adopted and the President appointed the following members to serve on this committee: H. H. Rusby, N. L. Britton, J. M. Coulter, F. V. Coville, L. M. Underwood, L. F. Ward and W. A. Kellerman.

The match had been applied to the nomenclatural kindling.

No record is extant of those in attendance at the preliminary meeting the previous evening, but the register of the Club shows that Lamson-Scribner, Sudworth, O. F. Cook, Morong, Robinson, Macbride, Bailey, Vasey, and Mohr were at Rochester, besides those appointed to the committee.

The episode illustrates Britton's propensity for translating ideas immediately into deeds. The preliminary meeting was held August 17, the resolution was presented and the committee appointed August 18, the report was made August 19 and adopted the same day. The opposition, if any there were, had no time to organize its forces.

We can hardly believe that the ideas embodied in the simple principles of nomenclature adopted at Rochester were entirely the result of a spontaneous discussion held the evening before. On the contrary, there is every reason for us to assume that the entire affair was premeditated, that Britton went to Rochester with the rules in his pocket, that the participants in the discussion were carefully selected by Britton, that Rusby was maneuvered into the vacant position of chairman so that the proper committee could be appointed, and that the work of the committee consisted merely in accepting, possibly with slight modifications, the rules which Britton had ready. Britton was always noted for Blitzkrieg tactics, but he was also characterized by a prudence in starting a campaign only when its success was assured. He once made the statement that he had never had a divided vote in the Board of Managers of the New York Botanical Garden; undoubtedly the chief reason for his success in managing the managers was the care with which every proposition was prepared and presented.

The Rochester Code, in its initial form, was simple. It adhered to the Paris Code of 1867, except where the latter conflicted with its eight

[2] A tautonym is a binomial in which the specific epithet exactly repeats the generic, as *Sassafras sassafras*. Such names were later the subject of heated discussion and were finally outlawed by the International Code of Botanical Nomenclature. They are accepted and freely used in zoological nomenclature.

brief articles. It accepted priority as the guiding principle in nomenclature, but insisted on priority of actual publication and laid down simple methods for determining whether a name was properly published. It prescribed the first edition of Linnaeus' *Species Plantarum* (1753) as the starting point of nomenclature. It required the retention of the original specific name in the transfer of a species from one genus to another. (Two exceptions to this requirement were embodied in the original draft; these were removed by amendment in 1893 at the Madison meeting.) It invalidated all later homonyms, restricting the use of each to the plant to which it was first applied. It required the use of the now familiar double citation, placing in parentheses the original author of the specific name, if first used in a different genus, and adding the author of the proposed combination.

Of the eight articles, six were adopted unanimously, either with or without extensive discussion; one was adopted by acclamation, "which was not unanimous," and another by a vote of fourteen to four.

Again following his usual principle of immediate action, Britton presented a motion calling for the continuance of the committee as a permanent committee on nomenclature charged with the preparation and printing of a list of the plants of the northeastern states in accordance with these recommendations. So energetically did Britton push this laborious task that the list was reported as nearly ready for printing a year later, and two-thirds of it was actually in type in two years. This list was one of the inspirations of the great *Illustrated Flora of the Northern States and Canada*, by Britton and Addison Brown, which will be discussed later.

The adoption of the Rochester Code was followed by shouts of approval and storms of protest. These came at first chiefly from research workers in systematic botany who were frequently confronted with the difficulties of choosing the proper name for a species. Others, who merely used without question the names which they heard or read, paid little attention to the controversy until the *Illustrated Flora* was published. Then with this new work and the sixth edition of Gray's *Manual* before them, they were compelled either to learn two names for a large number of plants or to make a choice between them. Probably many botanists, from lack of practical experience in taxonomic research, were unable to appreciate the logic of arguments on either side or to understand the problems involved. They were prejudiced in one direction by loyalty to the names of Gray's *Manual*, which they may have known for years, or in the other by the greater utility of the *Illustrated Flora*.

As a result, the botanists of the United States were soon divided into two camps and it would scarcely be an exaggeration to say into two hostile camps. The most unfortunate result of the arguments was the schism between two great centers of taxonomic research, the one the Gray Herbarium of Harvard University, the other the Herbarium of Columbia College, where Britton was Professor of Botany, and later the New York Botanical Garden.

The first indication of this breach appeared about 1895. The list of plants of the northeastern states had just been published, using names according to the new code of nomenclature. On this Dr. B. L. Robinson, of the Gray Herbarium, wrote a seven-page critique, in which he stated:

> It seems sufficiently evident that the new system, far from furnishing a satisfactory solution to the nomenclature question, fails even to offer such substantial advantages over the existing system as greater clearness and prospect of permanency, for which alone working botanists could afford to make such sweeping changes in their language.

To this, F. V. Coville replied a few months later, meeting Robinson's objections one by one and stating:

> It is to be regretted that Dr. Robinson did not while at the Madison meeting, bring forward for discussion his questions as to principles, for they undoubtedly were well understood, and would have been ably explained, by many of the botanists present. Now that they have been adopted by overwhelming majorities in democratic botanical assemblages, we may well ask whether Dr. Robinson's protest is not out of place, and whether he has any available substitute to offer or improvement to suggest. I feel justified in expressing the hope that Dr. Robinson and the few who think with him on this subject will lay aside personal prejudices and join the remaining nine-tenths of our botanists . . . in a nomenclature based on scientific needs and a scientific method.

At the Springfield meeting of the Botanical Club in 1895, nomenclature was again discussed, and Robinson alluded to certain generic names which he thought had been inconsistently used. On motion by Britton, the club voted to increase the committee on nomenclature to eleven members by the appointment of Robinson and C. S. Sargent. Robinson declined the position, because

of radical differences of opinion between himself and a majority of the present committee. His place was then filled by the appointment of L. H. Bailey.

The breach between the Cambridge and the New York botanists, to which all other working taxonomists were almost unavoidably parties and in which almost all botanists were partisan, thus unfortunately begun in 1895, continued for thirty-four years, until the retirement of Britton from the directorship of the New York Botanical Garden. To say that either side voluntarily fomented it or that either side refused gestures of appeasement made by the other, that either side was the aggressor or either the aggrieved, that either side was relentless or charitable, is happily now unnecessary. The cause of the dispute is now non-existent, the principles are no longer with us, the breach has been closed, and the two institutions again work together in harmony.

In one respect, botanical science in America was the gainer as a result of the dispute. When the directorship of the New York Botanical Garden was first to be filled, the two chief candidates were Britton and Sargent. Their rivalry for the position was not merely one of ability and personality; it was a rivalry of the American Code with the old school. Britton won the appointment and built up the great center of taxonomic research which constitutes his enduring memorial. Sargent built up the great center of horticulture and taxonomy at the Arnold Arboretum, of which he became the highly successful director.

The establishment of the American Code soon attracted attention and strenuous objection in England and was shortly followed by a renewed interest in nomenclature on the continent. The Botanical Garden at Berlin soon (1897) laid down a code of procedure for its own staff, differing considerably from the Paris Code of 1867 and in many important points similar to the American Code, as Britton was quick to point out. The turbulent Otto Kuntze stormed into the field with new and radical proposals. The European discussion culminated in the International Botanical Congress at Vienna in 1905, at which the principal business was the formulation of a new International Code. Various amendments to this code were made at the next International Congress at Brussels in 1910, without changing its fundamental principles. For our purposes the two codes may be considered as one.

The International Code accepted the general principle of priority as a basis for determining the correct name and adopted 1753 as the starting point in the nomenclature of flowering plants, in accordance with the American Code and with the approval of almost all botanists. It rejected tautonyms, which were permitted under the American Code, but required the maintenance of the original specific name wherever possible in the transfer of a species from one genus to another. It demanded a Latin diagnosis in the publication of new species. Its chief and most far-reaching deviations from the American Code were validation of the use of later homonyms and the establishment of a long list of conserved generic names, which were to be used without regard to their priority.

Just as Britton had seized upon the publication of the American Code in 1892 and 1893 and adopted it in his *Illustrated Flora*, so did Robinson and Fernald take advantage of the new International Code in the publication of their seventh edition of Gray's *Manual*. The code was adopted in 1905 and the new *Manual*, using names in accordance with its recommendations, appeared in 1908. In the wordy and often acrimonious discussion between the proponents of the new American Code and of the old Paris Code, the odds immediately turned in favor of the latter. They could now state that their names were international rather than provincial, while the new *Manual* presented the latest taxonomic views of two of the best students of American plants. Adherents to the American Code became steadily fewer and fewer. It became fashionable to sneer at the American Code as outmoded and outlawed and to ridicule the botanists who still followed it.

Nevertheless, Britton and his colleagues at the New York Botanical Garden, together with several other botanists of reputation in other institutions, went merrily on with the American Code. They continued to reject homonyms and to use tautonyms, they paid little or no attention to conserved names, they published scores of new species without the Latin diagnosis.

The first hint of organized revolt from the International Code came at the British Imperial Botanical Congress at London in 1924, following which a committee labored to formulate recommendations, not for a new code, but for amendments to the existing International Code. Nomenclature was wisely omitted from the agenda of the International Congress held at Ithaca in 1926, but when preliminary announcements of the next International Congress were distributed,

not only the British Committee but also various Americans were ready with numerous proposed amendments.

The Congress met at Cambridge, England, in 1930. The United States was represented by more delegates than any other nation except the British. For the first time, voting powers were assigned to the Americans commensurate with their number and with the importance of their botanical institutions.

Britton was then retired from active connection with the New York Botanical Garden and had passed his seventieth year. Consequently he did not attend the Congress and took no prominent part in the formulation or presentation of the proposed amendments. It is unnecessary to discuss the spirited debate which lasted a week, but the results were most striking. The use of tautonyms was rejected, contrary to the American Code, but exactly in line with the original presentation of the Brittonian principles at Rochester in 1892. The requirement of a Latin diagnosis was continued, but names published in defiance of the existing rule, largely by Britton and his colleagues, were validated. This requirement, of course, has nothing to do with the choice of a name. Maintenance of the original specific name in the transfer of a species from one genus to another was required wherever possible, just as under the American Code. The conservation of certain generic names was affirmed, contrary to the American Code. Most important of all, all later homonyms were invalidated, as by the American Code, thereby removing the chief difference between it and the old International Code.

In short, except for the two minor points of conserved names and tautonyms, the American Code became in effect the International Code.

Forty-two years had elapsed since Britton, Sterns, and Poggenburg had first introduced these principles into botanical nomenclature; forty-two years of stress and struggle, of animosity and antagonism. We can only imagine the satisfaction with which Britton heard the results of the Congress, since to the best knowledge of the writer, he never gave any oral expression to his thoughts. He had conceived an idea, he had preached and practiced what his logical mind regarded as right and proper, and he lived to see his idea adopted by an International Congress.

Before the end of the preceding century there often occurs in Britton's writings a reference to types. No definition of a type was then fully understood by him. Like most other concepts, the idea of the type was poorly formed in his own mind, and gradually grew as time went on and he was called on to solve many problems of nomenclature for which the type-method was essential. At the beginning of the present century there were few who knew what was meant in taxonomy by the word type and still fewer who appreciated its importance. Even as late as 1930, at the International Botanical Congress at Cambridge, it was clear that the type-method was still not understood by some.

Briefly stated, the type-method is as follows:

A species includes a large number of individuals. Exact study of these individuals sometimes indicates that they represent two or more species, rather than one only. In the division of this collective group into two or more species, which one shall bear the original specific name, and to which shall new names be given?

The type-method requires that the name shall be retained for the particular plant upon which the original author based his description of the species, and for all other plants associated with it in the same species. Similarly, in the division of a genus into two or more genera, the type-method requires that the original generic name be retained for one of the species known to the author of the genus, so that the name is used essentially in the sense of the author.

Britton was a consistent advocate of the type-method for many years. There were soon attracted to it several active American botanists, chief of whom were L. M. Underwood, O. F. Cook, and A. S. Hitchcock, and by 1930 practically every working taxonomist in America was fully convinced of the necessity of the type-method for the accurate assignment of names to taxonomic groups. So actively did American botanists advocate the type-method that it was incorporated into the International Code as adopted at Cambridge in 1930.

Probably no single principle of nomenclature is as important as the type-method in conducing to stability of plant names. Its logic is so clear and so undeniable that it transcends ordinary rules and becomes an axiom in taxonomic research. Undoubtedly it will continually be followed by taxonomists, even though it should be omitted from future revisions of the International Code.

No claim can be made that the final adoption of the principle was primarily due to the efforts of Britton; chief credit should go to Hitchcock, if to any one man. But credit must be given to

Britton for his large part in the inception of the idea and in its introduction to American taxonomy.

Since this article is designed to present an evaluation of Britton's work, and since he played such an important part in the eventual adoption of the existing rules of nomenclature, it is only fair now to inquire whether these rules are or will continue to be useful in attaining the desired end, namely stability of plant names.

The fundamental weakness in any code of nomenclature is the fact that it is made by a congress which adjourns and thereby passes out of existence permanently. Any rules which it may have made are subject to repeal by the next congress, depending on the course of botanical opinion in the interim. Some names which were valid under the Paris Code were invalid under the American Code; some of these were restored to legality by the International Code of 1905, only to be outlawed again by the International Code of 1930. If we may take the actions of preceding congresses as an omen of the future, we may then expect still further changes, with the resulting alteration of names. And all of this has been done and will be done in the desire for stability of plant names. Nomenclaturists have stubbornly refused to admit, or perhaps even to realize, that stability is attained only by the lack of change instead of by compulsory change of plant names.

It is obviously true that both the American and the International Codes are, or were, subject to amendment. In fact, certain of the provisions of the original American Code adopted at Rochester were soon amended. In general, however, the American Code admitted fewer exceptions to the principle of absolute priority than does the International. It was much more rigid, possibly to its detriment, and much more precise. It may justly be argued that its rigidity and precision were a deterrent to the introduction of amendments, which might lead to continual change of names, while the exceptions which are a fundamental part of the International Code are a standing invitation to the introduction of still other amendments in the future.

Most of the exceptions to a rigid system found in the International Code are concerned, directly or indirectly, with the principle of priority, that is, with the general requirement that the oldest name shall be used. In both codes priority is not absolute, but begins with the arbitrary date 1753, the publication of Linnaeus' *Species Plantarum*. A few reformers have advocated 1737 instead, the date of Linnaeus' *Genera Plantarum*, while a few have favored absolute priority without regard to date.

Both codes require the combination of the oldest valid generic name with the oldest available specific epithet. To this requirement the American Code permitted no exceptions, while the International Code excepts certain generic names, which are conserved in accordance with general usage in preference to older names, or which would be excluded from use as later homonyms. It also excepts certain specific epithets, which are excluded because they would lead to tautonyms when combined with the oldest valid generic name.

In this discussion of nomenclature, the use of the phrase "specific name" has regularly been avoided and "specific epithet" used instead. It is clear that a generic name is actually a noun, designating a group of species constituting a single genus, but without differentiating between them. On the other hand, a specific epithet, not combined with a generic name, is generally meaningless. For the actual designation of a species a binomial is necessary. It has therefore been argued that priority should be based, not on the oldest applicable terms taken separately, but only on the oldest binomial. This is the famous "Kew Rule," adopted years ago for the guidance of the botanists at the Royal Botanic Gardens at Kew, used extensively throughout the British Empire, and also followed by various botanists in America, notably by Asa Gray and his school.

Probably no other single provision in any code would be more conducive to actual stability of names than the Kew Rule. Under the existing International Code, and also under the now extinct American Code, the taxonomist is compelled to search the literature far and wide for the oldest specific epithet and to use it, when found, even though it displaces a well-known name of long standing. Nor can he ever be sure that he has actually found the oldest one, unless it be a name from Linnaeus' *Species Plantarum* itself. Under the Kew Rule, he need search only within the genus concerned and adequate indexes are available for the purpose.

The reader will have gathered from the preceding paragraphs three general ideas: the first, that the progress toward and final achievement of international agreement on the questions of nomenclature is praiseworthy; the second, that Britton was responsible for the inception of the movement to a greater degree than any other one

person; the third, that the nomenclatural principles which he advocated form an important part of the present International Code. For all these Britton deserves the highest commendation for his logic, his foresight, and his energy.

But the reader must by no means conclude that stability of botanical nomenclature at the present time is entirely Utopian. The ideal which botanists sought and are still seeking is stability of plant names, a stability which is cosmopolitan, so that the botanical work of ourselves and of our foreign colleagues is mutually intelligible, a stability which has endured from the past and will continue into the future, so that the writings of our predecessors are easily intelligible to us, as ours will be to the next generation. Such stability has not been attained, and never in the history of botany have nomenclaturists gone to such extremes in their mania to change names as in recent years, since Britton's death, under the direct encouragement and requirements of the current rules of nomenclature.

Had Britton realized the extent to which established names of familiar plants would be changed under the strict application of the principle of priority and under other minor rules of the present code, it is doubtful whether he would have proposed any change in the *status quo* of 1892.

BRITTON AND THE ILLUSTRATED FLORA

For more than fifty years the sole illustrated manual of the plants of the northeastern United States was the well-known *Illustrated Flora of the Northern United States, Canada and the British Possessions*, under the authorship of Britton and Hon. Addison Brown. The first volume appeared in 1896, the third and last in 1898; a second revised and enlarged edition was published in 1913. That the work was a success may be concluded not only from the thousands of copies which have been sold, but equally from its continued popularity as a work of reference among horticulturists, foresters, teachers, gardeners, students, and amateurs.

No manuscripts of Britton have been found which throw any light upon the conception or preparation of the *Illustrated Flora*. One who understands the botanical questions of the early nineties, Britton's attitude toward them, and his characteristic habit of immediately translating thought into action and action into accomplishment, can easily deduce the motives which led to its preparation.

The Declaration of Independence in botanical nomenclature was adopted at Rochester in 1891. A list of the plants of the northeastern states, named in accordance with these nomenclatural principles, was in preparation. The next step was to secure the actual adoption and use of these names by the botanical public. Asa Gray, of Harvard University, had only recently passed away: his word on matters taxonomic was still law to most botanists and the sixth edition of his *Manual* had been issued in 1890, just a year before.

Britton once said, "If I can write a better flora than anyone else, my names will be used, no matter what code of nomenclature I follow." While this statement was made thirty years later, he no doubt had it in his mind in the nineties. How could he produce a better flora than Gray's *Manual*? How could he, a young man in his thirties, compete successfully with the established tradition of half a century?

The answer which he reached was an illustrated flora, in which the value of the pictures as a means of ready identification of plants would outweigh the reputation of Gray's *Manual*. How and why Judge Addison Brown became interested in the project is also unknown. Judge Brown was an amateur botanist, a personal friend of Britton, a man of considerable means, but without the experience in botany which is necessary for the production of such an extensive work. The introduction to the second edition of the *Illustrated Flora* states that "The enterprise, projected by Judge Brown, and maintained and supervised by him throughout, has been prosecuted for the past twenty-two years. Its execution has been mainly the work of Dr. Britton." An almost identical statement, merely substituting the number six for twenty-two, appears in the introduction to the first edition. The second sentence of the quotation is undoubtedly true, but it is difficult for us to admit that the idea actually originated in the mind of Judge Brown, and the circumstantial evidence is certainly against it.

The statements quoted indicate that work on the *Illustrated Flora* began in 1890, according to the first edition, or 1891, according to the second. If the theory proposed as to the underlying motive of the work is correct, the year should be 1891. Again circumstantial evidence may be employed. Britton had been publishing in the *Bulletin* of the Torrey Club a series of articles entitled "New or Noteworthy North American Phanerogams." The third one of the series, appearing in 1890,

was devoted almost wholly to plants living naturally beyond the geographical limits of the *Illustrated Flora*. The fourth, fifth, and sixth, appearing in 1891 and 1892, were devoted, on the contrary, almost entirely to plants of that region. It seems clear that his field of concentration was changed abruptly just at the time of the Rochester meeting. His bibliography, also, shows a conspicuous decrease in the publication of actual research, beginning at the same time. It seems probable, then, that the production of the *Illustrated Flora* was part and parcel of his plans for a revision of nomenclature.

We shall never know Britton's *modus operandi* in the preparation of the text, since his last botanical associate of the period has gone. Legend has it that he left Columbia College, then in its old buildings on Forty-ninth Street, Friday evenings with a bundle of herbarium specimens under his arm, retired to his old home in Staten Island, and there worked almost continuously until Monday morning.

The production of such a work is a huge task, and Britton must have devoted every available moment to it. Every statement was the result of observation or measurement. Every name, every citation, every record of geographic distribution required careful verification. No reader of these lines can appreciate the time-consuming nature of such work unless he has personally engaged in taxonomic research. Those who have had such experiences may well marvel that so much could be accomplished in five years. The whole work is a convincing illustration of Britton's overwhelming desire to get work finished and behind him.

The same zeal for accomplishment was also the principal cause of errors in the *Illustrated Flora*. The chief errors were not in the text, for which Britton was personally responsible, but in the drawings. They were seldom concerned with the general habit of the plant or the larger features of its structure, but rather with small details. For that reason they seldom led to misidentification of the plant and scarcely interfered with the usefulness of the book. Many of them were corrected in the second edition.

The value of the *Illustrated Flora* to American amateurs and teachers can scarcely be overestimated. Its appearance led immediately to a revival of attention to our native flora and many amateurs owe their interest in botany to its use. A personal illustration may perhaps be pardoned. When the writer of this chapter was beginning his own botanical study, he met on a field trip a lad of seventeen with a green book under his arm, volume one of the *Illustrated Flora*. This lad proudly announced that he had taken up the study of the difficult genus *Carex*, using the *Illustrated Flora* for his guide. For more than fifty years since this amateur was one of our leading students of the genus.

Britton himself, in very modest terms, summarized the need, the use, and the effect of the *Illustrated Flora* in the introduction to his second edition. His statement is just as valid today as when written in 1913.

> To all botanical students, a complete illustrated manual is of the greatest service; always useful, often indispensable. The doubts and difficulties that are apt to attend the best written descriptions will often be instantly solved by figures addressed to the eye. The greatest stimulus, moreover, to observation and study, is a clear and intelligible guide; and among the aids to botanical enquiry, a complete illustrated handbook is one of the chief. Thousands of the lovers of plants, on the other hand, who are not botanists and are not familiar with botanical terms or the methods of botanical analysis, will find in the illustrations of a complete work the readiest means of comparison and identification of the plants that grow around them, and through the accompanying descriptions they will at the same time acquire a familiarity with botanical language. By these facilities, not only is the study of our native plants stimulated and widened among all classes, but the enjoyment, the knowledge and the scientific progress derivable from these studies are proportionately increased.
>
> Exploration and critical study have been greatly stimulated by the first edition, and much of the additional information now brought into the second edition was elicited by use of the first, by students all over the country.

While his development of the New York Botanical Garden stands as Britton's greatest contribution to botanical science in general, and his work on the flora of the West Indies as his greatest addition to botanical knowledge, the *Illustrated Flora* will always remain his highest service to botanists, both professional and amateur, of the northeastern United States, the region of greatest population and of greatest concentration of educational institutions.

THE NEW YORK BOTANICAL GARDEN

The establishment of an institution is not in itself a scientific achievement. It requires tact and perseverance and determination, but these qualities might be found in a financier or an architect. The New York Botanical Garden, on the contrary, provided facilities and opportunity

for the advancement of botanical knowledge and for this reason its establishment and development ranks as a botanical achievement of first magnitude.

It has always been considered and is almost certainly true that the first idea of a botanical garden in New York arose in the minds of Britton and his young wife. The attendant circumstances are well known. Henry H. Rusby had returned to New York from his first botanical trip into South America, bringing with him large collections of plants. The identification of these plants was attempted by him and Britton, working together at Columbia College. Their facilities were poor. Herbarium material from South America, to be used in comparison with Rusby's plants, was very scanty and entirely inadequate. Library facilities were equally deficient. As a result of the difficulties which they continually encountered, Britton and his wife took specimens to the Royal Botanic Gardens at Kew, England, for study. They were so impressed by the opportunities for botanical work at that old institution that they began to dream of a similar one in America. Probably their dreams were made roseate by the enthusiasm and imagination of youth, since both of them were still in their twenties. Probably they never anticipated the difficulties which they would meet before their plans could be brought into reality.

When they returned they presented their ideas to the Torrey Botanical Club. They must have been eloquent and persuasive, because "at a regular meeting of the Torrey Botanical Club, held January 8, 1889, the subjoined appeal was unanimously adopted and ordered to be printed for general circulation."

The "appeal" is a small four-page folder setting forth the desirability and advantages of a botanical garden, which it refers to as a "public botanic garden in New York City." It is rather modest in its proposals. "Fifty acres might be considered a reasonable amount of land for a New York botanic garden; half as much could be made to answer a good purpose; seventy-five acres would be none too much for its ultimate highest development."

It is interesting to note how little the purpose of the New York Botanical Garden of today has deviated from the hopes of 1889.

> The use of a botanic garden may be reckoned as of four sorts. First and foremost is the purely scientific and educational use. Subsidiary to this, but still of a marked degree of importance, are the pharmaceutical and horticultural uses, and lastly, the general use as a place of agreeable resort for the public at large.

The story of the hard work, the discouragement, the apparently insurmountable difficulties of the next few years cannot now be told. The last survivors of the campaign, Britton, Rusby, and Denslow, have passed on. We shall never know what tactics they adopted to gain eventually city support, or who were the influential friends who were able to get the proposal before the city administration. Probably Seth Low was one of them, since he was then President of Columbia College and was a power in politics, having already been Mayor of Brooklyn for three years. We know that Rusby was in the thick of the fight; almost certainly Britton was also.

There were four problems to be settled. The city administration must be convinced of the desirability of the project; ways and means must be adopted for putting the project into effect; the site must be chosen, and finally a suitable director must be secured. Today we do not know even the sequence in which these four questions were settled. It is a matter of history that the actual inception of the Garden hinged on securing an endowment of a quarter of a million dollars from private donors. Here Britton was invaluable through his personal acquaintance with the Vanderbilt family, but several years passed before the full amount was obtained. As to the site, public opinion, as voiced by the newspapers, at least, was divided between Central Park, Van Cortlandt Park, and Bronx Park. We do not know the circumstances which led to the selection of the last one. There were two candidates for the directorship and the campaign was a bitter one. Finally, as reported years later by Rusby, the Mayor of the city (probably William L. Strong) called an informal meeting in his office, where he could listen to the claims of both candidates. He was so impressed with the abilities of Britton, and so opposed to bringing in an outsider, that he threw his favor immediately to Britton.

The Garden received its first charter in 1891, and was rechartered in 1896. Since money for its operation was then available, Britton resigned his professorship at Columbia College and immediately began the organization of a herbarium and library in temporary quarters, first in downtown New York and later in a house on 201st Street near the present Garden. By the time the Museum Building was completed in 1901, he had

already secured large quantities of herbarium material, great amounts of museum material of all sorts, and an ample collection of books. Research in taxonomy, pathology, and physiology began immediately; physiological chemistry and genetics were soon added; publication of the *Journal*, the *Bulletin*, and the *Memoirs* proceeded. A laboratory was provided for graduate students of Columbia University and it was always full of students.

As the writer looks back on a close acquaintance with Britton extending over a period of nearly thirty years, he is impressed by certain features of Britton's administration, and in conveying these impressions he will need to use the first person.

Britton always had the confidence of his Board of Managers. He won this confidence largely by the care which he took in preparing a presentation to the Board. Every phase of the question was considered, often for weeks in advance. Many a time I have been in his private study in his old home on Decatur Avenue near the Garden when he was making ready for a Board meeting. He sat on an old couch and thought. He rose and paced the floor back and forth like a caged lion. The rug was visibly worn in his path. Now and then he asked me something, or told me how far he had progressed in his plans. Possibly he would reach a conclusion while I was there. Possibly, and especially if the matter pertained to the city administration in any way, he would postpone his study until he had consulted with some official of the Park Department or some one else who might have an idea on the receptivity of the city fathers to the project.

When he finally presented the subject to the Board, he was fully prepared. Every detail was worked out, every question could be answered clearly and immediately, every objection could be met convincingly. It is no wonder that he once boasted to me that he had never had a divided vote in the Board of Managers.

Secondly, Britton seldom undertook any activity at the Garden which could not be completed within a reasonable time. This was decided before the project was undertaken; after work had begun, he saw to it that it continued steadily to completion and publication. I have known staff members who left Britton's office discouraged because some particular project was disapproved. A few were vetoed because he believed they were beyond the capability of the man or the facility of the institution; more of them were denied because it seemed probable that they could never be finished.

Thirdly, he had an uncanny ability in appraising a young man and judging whether or not he would succeed as a member of his staff. I was personally acquainted with every member of his scientific staff to the time of his retirement, and in that period he made just one poor appointment. There were during this period four instances of a man not adapted to the needs of the Garden or to the work to which he had been assigned. Each of these men was transferred to a different position or recommended to another institution, where each of them added notably to his own reputation and to botanical knowledge.

Lastly, he never neglected his own botanical research. He never became an administrator only; to the end of his career he remained a botanist. His method of work may be recorded. Every morning he appeared at the office at ten minutes after nine and conducted a staff meeting at which all major members of the staff were present. Then for two hours or sometimes more he considered administrative matters in his office. When he had properly attended to the affairs of the day, he appeared in the herbarium and went immediately to work on a pile of herbarium specimens. At one he went to lunch. At two the superintendent of grounds called for him in a car and he inspected every part of the garden. At three or four or even later he was back in the herbarium where he worked till seven. After dinner he retired to his study and spent the evening and sometimes a good part of the night in considering Garden affairs.

It has been said before and it may appropriately be said again that the New York Botanical Garden is and will remain a monument to the energy, the hard work, the thought, and the foresight of its first director.

BRITTON AND THE WEST INDIAN FLORA

Our knowledge of the flora of a region passes through three stages during the course of its development. While the transition from one stage to the next is gradual, often covering a period of many years, the three are nevertheless distinct, each being characterized by a different kind of investigation.

The first of these is the period of discovery, during which botanists explore the region, collect the plants as extensively as opportunity permits, name the species as best they can, and

describe the unknown ones as new. Lack of adequate material and insufficient acquaintance with the flora often lead to misinterpretation of the species. Previously known plants are often given new names; unknown species are often erroneously combined with others or are given more than one name each by independent students. Published literature dealing with the flora of the region consists largely of short articles or scattered descriptions. Summaries of the existing knowledge are usually mere lists of species or frankly admit that the flora is still only fractionally known.

With the lapse of time, continued field work yields ever fewer "new" species and adds less to the known flora of the region. The second stage is reached when it seems apparent that the production of nearly complete descriptive floras of the region are possible. Such floras represent the results of the collective efforts during the pioneer stage; they tend to eliminate synonyms and to give a general view of the flora as a whole. By providing in convenient form keys by which the names of plants may be ascertained and descriptions by which the application of names may be confirmed, these floras act as a stimulus to further study, to the accumulation of more herbarium material, to better knowledge of variation within the species, and often to the discovery of additions to the known flora.

During the final stage the flora is essentially completely known and the attention of botanists is directed largely to discovering and cataloguing minor variations.

As far as the eastern United States is concerned, the first period passed gradually into the second during the middle of the nineteenth century, and the second is even now passing gradually into the third.

The West Indies have lagged nearly or quite half a century behind. Botanical exploration began, to be sure, as early there as in the United States. During the eighteenth century Patrick Browne and Olof Swartz wrote extensively on the flora, but their work was very incomplete. William Hamilton attempted a flora in 1825; Francisco Adolpho Sauvalle compiled a flora of Cuba in the middle of the nineteenth century; August Heinrich Rudolf Grisebach published his flora of the British West Indies in 1864. These also were grossly incomplete. Charles Wright was even then collecting scores of undescribed and unnamed species in Cuba, while hundreds of other species in other islands were still unknown and many others were misinterpreted. The second stage in the botanical history of the West Indies had not been reached, and was not reached until 1910, when William Fawcett and Alfred Barton Rendle published the first volume of the *Flora of Jamaica*.

Britton entered the West Indian field shortly after the turn of the century. The great *Illustrated Flora* was completed, published, and on sale. To him the flora of the northeastern United States was thenceforth a closed issue. He would have been among the first to recognize the opportunity for further work there, the addition of species which barely crossed the conventional boundary line, the recognition of minor varieties and forms, the more discriminating study of such complex groups as the violets, hawthorns, asters, and goldenrods. But he understood the law of diminishing returns and knew that in quantity and usefulness the results of such work would be limited.

The United States took possession of Puerto Rico in 1899. American capital and American citizens were being established in Cuba. The whole of the West Indies, now definitely in the public eye, lay before him, easily reached by the steamers from New York Harbor. What region could be more accessible or more appropriate for study by the energetic young botanists of the newly organized New York Botanical Garden?

Of these young botanists, Small, of whom Britton wrote [3] "My man Small is the best collector extant," was already absorbed in the flora of the southeastern states, as was Rydberg in that of the Rocky Mountains. Howe's interest in algae was general rather than localized. Britton took the new field unto himself and labored at it almost continuously for more than thirty years. He did not try to monopolize the field. Each member of his staff was encouraged to study his own special group of plants as it existed in the West Indies, as Howe for the algae, Earle and Murrill for the fungi, Mrs. Britton and Williams for the mosses, Nash for the grasses, Rydberg for the legumes. Opportunities were freely given and often deliberately made for other botanists, outside the New York Botanical Garden, to share in the work, so that the completion of the project could be expedited by the use of their own special knowledge. The few resident botanists of the West Indies were stimulated to greater activity, largely by personal contact with Britton's enthusiasm, but also by purchase of specimens and by subsidies for their work.

[3] Letter of Oct. 13, 1893 to Prof. Wm. W. Bailey.

From all the young botanists who were concerned with the West Indian flora, Britton chose one to be his personal assistant, his invaluable aide, and later his collaborator. This man was Percy Wilson. While to Britton must go full credit for the plans of the West Indian work, for the development of ways and means to accomplish it, and for the relentless energy to carry it on, it is certain that the amount of work accomplished in thirty years was made possible by the industry, the continuous application and the uncanny memory of Percy Wilson. Certainly no botanist was ever more fortunate in the choice of an assistant than was Britton.

Wilson entered the service of the New York Botanical Garden at the age of twenty, without botanical training or experience, and served it for forty years, with the exception of one year at the Cuban Experiment Station. His knowledge of the West Indian flora was acquired partly by field experience but chiefly by handling herbarium specimens. Gifted with a remarkable memory and with a good eye for specific characters, he soon developed a wide acquaintance with the flora.

If the West Indies were still in the first stage of their botanical development, the first task for Britton would naturally be the thorough collection of plants. This task was taken up immediately. From 1898 to 1916 no less than seventy-three expeditions were sent into the West Indies, including a hundred and thirty-one persons, an average of about two botanists to each party. Britton made no less than twenty-five such trips himself and on all but two he was accompanied by Mrs. Britton. There were nineteen expeditions to Cuba, fifteen to Puerto Rico, twelve each to Jamaica and the Bahamas, eight to Bermuda, four to various islands of the Lesser Antilles, and three to Hispaniola.[4] After 1916 West Indian exploration was greatly restricted, although Dr. and Mrs. Britton spent a month or two there every winter, often accompanied by one or two other botanists, and invariably returned with quantities of botanical specimens.

It is impossible to ascertain how many West Indian specimens were added to the herbarium of the New York Botanical Garden as a result of these numerous expeditions. Official reports of some of them state the number collected. Using these figures as a guide, the total may be estimated at about 150,000. Large numbers of duplicates were also obtained and used in exchange for other West Indian material, so far as it was available. Excellent collections were thus acquired from various islands, but especially from Jamaica, Cuba, and Trinidad. Other thousands were obtained by purchase and by gift. The West Indian collections at the New York Botanical Garden soon became by far the largest in the Western Hemisphere and possibly the largest in the world.

Most of the expeditions to the West Indies were purposely sent to districts which had not been adequately explored, so that the flora was incompletely known. As might be expected, numerous species of plants previously unknown to botanical science were collected, returned to the New York Botanical Garden, and there described and named by Britton and his colleagues or by specialists elsewhere at Britton's request. It is impossible to estimate how many undescribed species were thus detected, but the number must amount to some hundreds. In the flora of Puerto Rico, for example, about 112 species, or approximately five per cent of the total, represent new discoveries. This is particularly impressive when it is recalled that Ignatz Urban, of Berlin, had made special study of the flora for several years preceding and had already published, with various collaborators, almost two hundred new species. In the Bahama Islands, everywhere of low altitude and populated by the widespread lowland flora of the West Indies, 143 species, or about fourteen per cent of the total flora, were first made known to science through material collected by or for Britton during these expeditions. There is no means of ascertaining how many known species were collected for the first time in these islands or in Puerto Rico, although already known elsewhere, but the number must be great. Similar statements could be made concerning the work in Cuba and Jamaica, where exploration was active, and, subject to reasonable limitations, in all other islands to which Britton sent expeditions.

The reason for the success of the expeditions is found in their organization. Britton chose men who were young, strong, and zealous. They were sent not to a base in some hotel in Havana, San Juan, or Nassau, but far afield to small villages, remote plantations, or peasant houses back in the hills. He sent the same men repeatedly, so that they, as their experience increased, knew what to take and what to neglect. Their collections were rich as well as extensive.

[4] The sum of these figures is more than seventy-three, since many expeditions visited two or more localities.

By 1916, when exploration was greatly reduced, the flora of the West Indies was remarkably well represented in the herbarium of the New York Botanical Garden. Of the Greater Antilles, only Hispaniola lagged. The flora of the Lesser Antilles as a whole was adequately represented, but several of the numerous islands had been neglected, especially Dominica, with perhaps the richest flora of all. Jamaica, Cuba, Puerto Rico, Bermuda, and the Bahamas were ready to enter the second stage in their botanical history and Britton was anxious to turn his energy to the production of comprehensive floras.

Of these the first to be published was the *Flora of Bermuda* in 1918. It contained 585 pages and described and illustrated each of the 448 seed-plants, the 21 ferns and fern-allies, and the 50 bryophytes. It also listed and briefly described the numerous species of plants in cultivation, specifically mentioned and excluded from the flora the species which had been erroneously attributed to the islands, and discussed in more general terms the fungi and algae as far as they were known. For the lower plants Britton had the cooperation of Mrs. Britton, Alexander W. Evans, and Marshall A. Howe. The book has been continuously useful not only to residents of the islands and to professional botanists in general, but also, because of the growing importance of Bermuda as a tourist resort, to every botanically-minded visitor.

Britton's attention was next turned to the flora of the Bahamas. Nine expeditions had been sent to various parts of these islands. During one of these and on three other occasions the New York Botanical Garden had also sponsored exploration by the Bahama botanist, L. J. K. Brace. Numerous specimens had also been received from other sources and the older collections had been made available to Britton for study. The *Bahama Flora,* written by Britton and Charles Frederick Millspaugh, of the Field Museum of Natural History and published by the authors, appeared in 1920. The flowering plants of the Bahamas numbered slightly more than a thousand species and with them were included almost as many flowerless plants, making a total of nearly two thousand species. Although without illustrations, the book contained 695 pages.

The *Flora of Puerto Rico and the Virgin Islands,* by Britton and Wilson, published as a part of the Scientific Survey of those islands, was a still more ambitious work. The first part appeared in 1923; it was followed by others in rapid succession and was completed in 1926, although a supplement of some fifty pages was published in 1930. The flowering plants, treated by the authors personally, comprised slightly more than two thousand native or naturalized species. To the descriptions of these were appended notes on approximately eight hundred other species, most of which had been found in cultivation there by the senior author, while the others were species erroneously reported from the islands. The ferns and their allies, treated by William R. Maxon, of the United States National Herbarium, constituted an additional 278 species.

Measured by the number of species concerned, the flora of Puerto Rico and the Virgin Islands is twice as large as that of the Bahamas, which in turn doubles the flora of Bermuda. With these comparatively small tasks behind him, Britton started at once on a far more difficult project, the compilation of a flora of Cuba. Stretching nearly eight hundred miles from east to west, reaching altitudes above six thousand feet, approaching close to Central America at its western end, with rainfall varying in different parts from very dry to very wet, with a great variety of soils, and with mountains of great age and consequent high endemism, Cuba has a flora greater than any other island of the West Indies with the possible exception of Hispaniola. To secure adequate representation of this flora Britton had already sent nineteen expeditions into all parts of the island. Besides the thousands of specimens thus obtained, thousands more had been acquired by purchase or exchange, notably from the active Cuban botanist, Brother León.

On the basis of this material and the publications of reputable botanists, Britton and Wilson with the collaboration of Hermano León of the Colegio de La Salle, Havana, began the preparation of a flora of Cuba. This took the form of a manuscript catalogue, in which keys to the species were provided under each genus, while every species was accompanied by its synonymy and a statement of its geographic distribution. After Britton's retirement in 1929 the catalogue was kept constantly revised by Wilson until he also retired in 1939. It ultimately comprised about seven thousand species. At all times the catalogue was essentially ready for the press, but actual publication was impossible because of the general financial stringency of the decade.

If and when a descriptive flora of Cuba is published, Britton and Wilson will not be the authors, but they will go down in botanical history

as the two men whose indefatigable energy made such a publication possible.

Similarly Britton undertook to produce a flora of Trinidad, working in cooperation with Trinidad botanists. He retired from active participation when the project was taken over by the Trinidad colonial government. Actual publication of the work has begun.

Britton's personal interest in the flora of the West Indies was chiefly restricted to the higher plants, but through his position as Director of the New York Botanical Garden and his close connection with scientific institutions and governmental agencies in the West Indies he often made possible important botanical studies on other groups or of a different nature. Among these may be mentioned the extensive studies of West Indian mosses by Mrs. Britton, who accompanied her husband on almost every expedition and made large collections; the collection and study of the diatoms and myxomycetes of Puerto Rico by Robert Hagelstein; the important basic work on tropical algae by Marshall A. Howe, which is classic in the subject; the studies of tropical fungi by F. S. Earle and W. A. Murrill, and the ecological survey of Puerto Rico by H. A. Gleason and Melville T. Cook. Britton was also keenly interested in the establishment and maintenance of the Tropical Research Station at Cinchona, Jamaica, where much botanical work has been accomplished.

While the great herbarium of West Indian plants at the New York Botanical Garden was established primarily for the use of members of the Garden staff and furnished the material for much of their research, it also served and continues to serve in another important way in aiding many students of other institutions. The *Flora of Jamaica*, for example, was published in England under the authorship of British botanists, to whom Britton made available his own rich collections whenever needed.

Little adverse criticism of Britton's work on the West Indian flora has been expressed. One writer without experience in the West Indies, made some scathing remarks about the unnecessary description of so many new species, forgetting that Britton's men were penetrating parts of the islands which had never been botanically explored and which were certain to yield numerous unknown plants.

One regrettable feature of his whole West Indian program was his rivalry with Ignatz Urban, of the Botanisches Museum at Berlin. Before Britton entered the West Indian field, Krug and Urban had already begun work there. Krug died in 1898 and Urban continued his studies almost to the day of his death in 1931. Most of their results were published in a series of extensive papers collectively known as *Symbolae Antillanae*, which eventually comprised eight thick octavo volumes. Like many other German works, this series is characterized by long and detailed descriptions of plants, full citations of collectors and localities, and extensive discussions of specific relationships. In all of these features the work of Britton stands in sharp contrast by its short and pithy descriptions, meager citations, and scant attention to matters of comparison and kinship. Britton's work was produced not hurriedly but quickly; his species were left defined more by their representative specimens than by their descriptions. He had little faith in the recognition of species by printed statements alone, and insisted on actual specimens for comparison. The diagnoses which accompanied the publication of his new species were merely a detail in compliance with botanical custom.

If Britton could have done so, he would have extended the Monroe Doctrine to botanical research. Since this was impossible, he lost no opportunity to secure to this country any advantages which might arise from priority. On some occasions duplicate collections were sent to New York and Berlin at the same time. Before Urban could complete his minute dissections, his ponderous descriptions, and his erudite discussions, Britton had his brief diagnoses actually in print and the type specimens, christened with a Brittonian name, safely deposited in the herbarium at the New York Botanical Garden.

NORTH AMERICAN FLORA

The New York Botanical Garden was scarcely under way before its first great botanical project was started. That was the publication of a comprehensive flora of the entire continent.

Up to that time various parts of the continent had been covered by local floras. Gray's *Manual* covered the northeastern states and was already in its sixth edition; Britton's *Illustrated Flora* covered the same area and extended north into the Arctic. Chapman had published a flora of the southern states and Small was just ready with his new flora of the same region. There was a flora of California and another of western Texas; Hemsley had listed the plants of Central America, and there was Grisebach's *Flora of the British*

West Indies. Great expanses of land had never been covered by any single flora. There were various monographic studies of certain families and genera, mostly by European authors. Such books discussed all the plants of a region or all the plants of a definite botanical group. There were also in print hundreds or thousands of scattered articles in the literature of Europe and America, in which species were described or genera and families discussed, or the plants of a single collector or a single expedition catalogued. Such literature was available in only a few specialized libraries in the United States, and the published floras, except for the eastern third of the United States were incomplete or out of date. As a result, it was virtually impossible for the student to identify a plant from any other part of the continent or to determine that the plant was undescribed and as yet without a name. Moreover, the scattered literature, the work of many different botanists in various institutions of Europe and America over a period of a century or more, had often created or perpetuated confusion. Plants had often been named twice or even more times, wrong identifications were rife, names had been misapplied.

Every working taxonomist knows the familiar sequence of events in the development of knowledge of a particular group of plants. One botanist publishes a summary of the group, bringing all information about it together and up to date. This serves as a guide in the following years. But new botanical expeditions go into other parts of the world and collect more plants. Through misinterpretation of the previous author's statements, through misidentification of plants, through erroneous assignment of unnamed plants to species already described, and through superfluous description as new of plants already known and named, confusion soon appears and steadily increases until another specialist again sets the group to rights.

North American Flora was designed to remedy this unfortunate condition, at least so far as North America was concerned. It was not intended to be a final and definitive flora of the continent; such a work would be impossible until every nook and corner of the territory had been thoroughly explored. It was to be merely a summary and a correlation of the knowledge already obtained, a summary which would serve as a ready guide to the accumulated knowledge of the past and as a point of departure to further work in the future.

It is not known whether the original idea of such a monumental publication was developed by Britton or by Lucien M. Underwood, then Professor of Botany in Columbia University and an authority on the taxonomy of ferns. Britton certainly approved of it as a worthy service of the Botanical Garden and the managers of the Garden authorized it. Work was begun at once by the assignment by Britton of certain families to members of the staff and the first results were in print early in the century. After half a century the work is still far from complete. The desirability of such a work is as great as ever and the demand undoubtedly much greater.

It may be interesting to note that similar work on even a larger scale has been undertaken by the Dutch for the huge flora of the East Indies, with the expectation of completion in a century, and in Brazil, also with a flora larger than all of North America. If and when *North American Flora* is completed, it will be comparable to the *Flora Brasiliensis* and will stand as the most extensive contribution of the New York Botanical Garden to the knowledge of plants.

FLORA OF NORTHERN SOUTH AMERICA

The general similarity in the flora of the various islands of the West Indies is well known to plant geographers. The numerous species constitute a definite and distinct geographic group which extends from western Cuba and extreme southern Florida east and south throughout the Greater and Lesser Antilles. The layman, who ordinarily regards Trinidad as one of the West Indies, seldom appreciates that the flora of this large island is South American rather than West Indian. The coastal Andes of Venezuela, extending east and west along the south shore of the Caribbean Sea, are broken toward the east by a deep defile which extends below sea-level. Only the very narrow strait of salt water which occupies this gap separates Trinidad from the Venezuelan mainland. The flora of the mountains of Trinidad is essentially the same as that of the Venezuelan coast ranges, and the plants of the lowlands of southern Trinidad are distinctly those of the Amazonian forests which extend along the coast of the Guianas as far as the mouth of the Orinoco.

These facts of plant geography soon became apparent to Britton when he undertook the study of Trinidad plants. For the proper identification of many such plants he needed to make comparisons with species from Venezuela and the Guianas and these were poorly represented in the

herbarium of the New York Botanical Garden. There were similar close relations between the flora of Costa Rica, Panama, and of Central America and that of Colombia in South America, and Colombian material was often desirable or necessary for the proper interpretation of the Central American species. In 1917 this need became more acute through the accession of nearly five thousand herbarium specimens collected in Colombia by Henry H. Rusby and Francis W. Pennell.

These circumstances, and probably other similar ones, led Britton to extend the sphere of the New York Botanical Garden to include northern South America, defining the region as the countries of Ecuador, Colombia, Venezuela, British Guiana, Surinam, French Guiana, and Trinidad. In 1918 an informal agreement was made with the National Herbarium and the Gray Herbarium of Harvard University for the cooperative study of the flora. For several years this work received much of Britton's attention and was actively prosecuted along two general lines, the collation and coordination of existing knowledge and the extension of knowledge by exploration and research.

Since the older collections are almost entirely in Europe, the first of these lines necessitated travel and study abroad, where specimens from American herbaria might be compared with the authentic material of the early collectors, upon which all published information has been based. Britton himself made one trip to England and sent H. A. Gleason, of his staff, three times for extended periods. Other botanists of the two cooperating institutions also spent considerable time in Europe for the same purpose.

Of equal importance, but of much greater interest to the average citizen, is the work of extending knowledge through botanical exploration and collection. To that end, the three institutions repeatedly sent botanists into South America, who in some cases revisited the collecting grounds of the early explorers in order to duplicate their material, and in others entered botanically unknown territory. The New York Botanical Garden, on the advice of Britton, sponsored wholly or in part twelve such expeditions which entered every country of the region except Surinam.

In this work Britton personally took little active part. He was keenly interested in the study of the first collections, when for correct identification the experience of the master was necessary. Accompanied by John A. Shafer, then of the Garden staff, he had previously made a short trip to Curaçao and the adjacent Dutch islands in 1913, and he visited Trinidad in 1920 and 1921, securing large collections. Britton also encouraged the work of local collectors in several South American countries, receiving some thousands of specimens from such botanists as Henri Pittier in Venezuela and W. E. Broadway in Trinidad, and other thousands from such local collectors as J. S. de la Cruz in British Guiana. Through his interest in all phases of the work, the collections at the New York Botanical Garden were increased from a scant ten thousand specimens in 1916 to approximately a hundred thousand at the time of his retirement in 1929.

The study of these collections led to extensive publication, but this was restricted chiefly to description of previously unknown species and to monographic studies of limited groups, partly by Britton himself but largely by the members of his staff to whom the work was entrusted. His chief personal contribution was a scholarly account of the important families Mimosaceae and Caesalpiniaceae, written in collaboration with Ellsworth P. Killip, of the National Herbarium, and published in 1936, after his death.

Probably his activity in this project may best be summarized by stating that he made American institutions largely independent of European herbaria in the study of the flora of the region. While type specimens and the older collections will always remain in Europe, if not destroyed by the ravages of war, American herbaria now lead in quantity and quality of material and American botanists now lead in their knowledge of the plant life of this important sector of our hemisphere.

NORTH AMERICAN TREES

Another useful botanical work by Britton was his *North American Trees*, a large octavo volume of 894 pages and 781 figures, describing all the native trees of extratropical North America, published in 1908. That this work never attained the popularity which it deserved may be understood from the conditions at the time of its publication. It had been preceded only three years by the *Manual of the Trees of North America*, by Charles Sprague Sargent, author of the magnificent *Silva of North America* and Director of the Arnold Arboretum, an institution which specialized in woody plants. It was contemporaneous with the new edition of Gray's

Manual by Robinson and Fernald, which also included the trees of the northeastern states, the region of densest population. In nomenclature it followed the American Code, at a time when that system was at the lowest ebb of popularity. Nevertheless, in its treatment of the species of trees, Britton's book often showed a distinct improvement over Sargent's *Manual;* in fact, many of these improvements were accepted and followed by Sargent in the second edition of his *Manual* in 1922.

The title page of *North American Trees* states that the book was written with the assistance of John A. Shafer, then custodian of the Museum at the New York Botanical Garden. Shafer was a man of considerable field experience, an excellent collector of plants, and gifted with an ability to distinguish and evaluate species. It seems probable that much of the spade work necessary to the production of such a comprehensive book was done by Shafer, while the actual text is wholly the product of Britton's pen.

MONOGRAPHIC WORK

There is an essential difference, well known to taxonomists, between floristic work, exemplified by Britton's *Illustrated Flora* and his various books of West Indian floras, and revisionary or monographic work on a single group of plants. The former is limited geographically but is broad and inclusive in its scope. It may be almost wholly compiled from existing sources of knowledge or may represent chiefly original work. The latter, on the other hand, attempts to bring together all existing knowledge of a taxonomic group, to weigh and evaluate it carefully, to examine critically all available herbarium material, and as a result to present a complete taxonomic picture of the group according to the matured judgment of the author.

Britton's first efforts at monographic work were directed to the Cyperaceae, the sedge family, a large and cosmopolitan group of plants, resembling grasses and including perhaps four thousand species. Although he always retained his interest in the sedges and described a number of new species, he never completed any extensive work upon them other than the treatment of the family in his several floristic works. Sheaves of manuscript left in his study at the Botanical Garden are evidence of his intention to publish extensive and important studies of the group, including revisions of some of the genera and a comprehensive treatment of all genera (except *Carex*, assigned to Kenneth Kent Mackenzie) of the continent for publication in *North American Flora*. This is apparently the only botanical project which he began and failed to complete.

The reason for this exception in a lifetime of achievement is to be found in restricted time for research and the desire to use this time in the most useful way. Aside from a number of short works, chiefly intended to fill small gaps in *North American Flora*, his chief efforts during his last forty years were devoted to floristic work and to monographic study on three groups of plants, all of considerable interest and value in economic botany and horticulture. The work in each case was carried on in collaboration with other botanists.

Of these the first was the work on the Crassulaceae, or Stonecrop family, in collaboration with Joseph Nelson Rose. This is a considerable group of herbaceous plants, usually succulent, with thick fleshy leaves and stems, many of which are highly ornamental and therefore favorite objects of cultivation in greenhouses, window gardens, and rockeries. Quantities of living material were obtained by Rose during his various trips into tropical America, especially the mountainous parts of Mexico, and these plants were grown in the conservatories at the New York Botanical Garden. From this living material and from herbarium specimens at the Botanical Garden and the National Museum, the two men produced the account of the Crassulaceae of North America, published as a part of North American Flora in 1905. This has since served as a foundation for further studies of the group and has become increasingly important as horticultural interest in the plants has developed. With the publication of this joint paper Britton's interest in the Crassulaceae ceased.

Daniel Trembly MacDougal was the first Assistant Director of the New York Botanical Garden and left it to become Director of the Desert Botanical Laboratory, maintained by the Carnegie Institution at Tucson, Arizona. It was to be expected that he would be attracted to the cacti as suitable subjects for botanical study and that he would soon realize that the Cactus family was sorely in need of taxonomic study. MacDougal was a close friend of Joseph Nelson Rose, who had experience as a botanical collector and had had already shown interest and ability in the taxonomy of succulents. He was a member of the Scientific Directors of the New York Botani-

cal Garden and understood what facilities of library and greenhouses were available there.

The project was initiated in 1911. Rose was given leave of absence from the National Museum in 1912 and for several years thereafter devoted his time to the cacti. He made several trips into American deserts as far south as Argentina and collected hundreds of living specimens. Financial support for him came primarily from the Carnegie Institution. The New York Botanical Garden gave freely of the time of its artist and its photographer and supplied space and labor in the greenhouses. It seems that contributions toward Rose's traveling expenses were also given by the United States Department of Agriculture, the National Museum, and the Gray Herbarium of Harvard University; the amounts have not been ascertained. Rose was able to collect miscellaneous herbarium material to a limited extent, and it is probable that the National Museum and the Gray Herbarium shared in it.

As the plants came into bloom, they were painted or photographed and carefully described. Important organs were preserved dry or in liquid. The taxonomic study was pushed rapidly to completion and published in four sumptuous volumes, profusely illustrated in color and with numerous text figures in black and white.

It is difficult to form an opinion concerning the extent of Britton's participation in this work. Probably considerably more than half of the taxonomic study was by Rose, who had all or most of his time available for it. Obviously the contribution of salaried time and greenhouse space by the New York Botanical Garden was of great value. After the publication of their results, Rose returned to the National Museum and Britton evinced little further interest in the cacti. Instead he turned to the study of two other families of plants, again in a cooperation with Rose which continued until his death in 1928.

These were the Mimosa family and the Caesalpinia family, two large and closely related groups of plants, including chiefly trees and shrubs and growing in greatest variety in warm climates. They form an important element of the forests thoughout tropical America. Many of them are important as the source of lumber, gums, and dye-stuffs. Others are popularly planted as street trees in tropical cities and some of them rank among the most ornamental flowering plants through their copious production of brilliant flowers. Among the latter the Acacia of our northern greenhouses and the Royal Poinciana of southern Florida are especially familiar. Britton knew the need of taxonomic study of these plants from his contact with them in the West Indies, but the opinion is probably warranted that he was also influenced by their economic value. It was well, as a matter of Botanical Garden policy, to show that the research at the Garden had a practical application.

The study of these plants was carried on chiefly from the huge quantities of herbarium material in the great collections at the New York Botanical Garden and the National Herbarium. The results were published in *North American Flora* and extended to 349 pages.

After the death of Rose, Britton continued his study of the same families as represented in South America, now in collaboration with Ellsworth P. Killip of the National Herbarium. All of his research time during the few years of his retirement was devoted to this work and an account of the Colombian species was published under joint authorship in 1936.

Britton's monographic work, while sometimes leading to imposing results, was clearly subordinate to floristics. His chief interest, during his entire connection with the New York Botanical Garden, lay in the exploration of tropical America, the identification of the plants collected, the publication of numerous short articles describing and discussing the plants, and the summarization of his work into extensive floristic works.

EIGHTEENTH-CENTURY CONCEPTS OF THE ORIGIN OF SPECIES*

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EVOLUTIONARY concepts are inescapably related to the nature of biological species—to its hereditary aspects, to the limits to its variability, to the very idea of a biological *kind* of plant or animal. Already by the beginning of the eighteenth century certain great controversies had developed to a point where the fixity of species was becoming the prevailing view. One of these controversies revolved about the occurrence of spontaneous generation, an ancient belief which Aristotle had supported. The other was an attack on another Aristotelian view, the idea that the nature of development in an animal is an epigenesis, a formation of the embryo or foetus from previously formless matter, through the action of the formative principle of the male (Dynamis) upon the nutritive substrate secreted by the female.

Before men could believe with full logic in the constancy of species, the ghost of spontaneous generation had to be laid. Redi's famous and conclusive experiment of 1668, which showed that the maggots that hatch into flies arise exclusively from eggs laid by parent flies, was confirmed by Leeuwenhoek, who affirmed that even the tiniest animalcules or bacteria under his lens were generated from parents of their own kind. Swammerdam, Malpighi, and Vallisneri, the great microscopic anatomists of the same period, attacked the problem of the generation of gall-flies inside plant galls; and Malpighi and Vallisneri, master and student, discovered the remarkable ovipositors wherewith gall-flies lay their eggs inside of plant buds or between the layers of leaves, and provoke the plant to form protective galls surrounding the developing larva of the insect. Although these keen observers had to admit themselves baffled in regard to the origin of intestinal worms, they boldly extended their disbelief in spontaneous generation to encompass these creatures too. In some mysterious fashion even intestinal worms must have reproduced without discontinuity since the beginning of time.

If the embryo was preformed in the egg, as their studies led Swammerdam and to some extent Malpighi to believe, the character of species was fixed at first creation. Hereditary variation, or even progression within the species, might remain possible, providing Providence had seen fit to endow the still unhatched germs of the future with such differences; but the transformation of one species into another, or the origin of one from another, was surely excluded. As the scientific disproof of spontaneous generation thus led to the dominance of the doctrine of preformation, as being less vitalistic than a belief in epigenesis, so the acceptance of preformation in turn led to the rejection of evolutionary views, which seemed to require some sort of "new generation." The objection was in both cases to teleology, to the postulation of final causes, and to the necessity of calling on vague and indefinable agencies of a non-physical character, such as the "formative faculty" postulated by William Harvey or the "vis essentialis" of Caspar Friedrich Wolff. There is little question about the relative merits of the opposing hypotheses during the seventeenth century. The mechanistic view of the preformationists was in its day a far more scientific, experimentally testable idea than the vitalism of the epigenesists and the unsupported speculations of the transformationists.

Thus, at the commencement of the eighteenth century, the dictum "no new generation" spawned the dogma "no new species." The opposing concepts seemed contradictory and utterly irreconcilable, though time was to prove this false. For epigenesis and preformation would one day attain a modern synthesis embracing them both; and the mutation of the elements of preformed pattern would be seen to supply the hereditary variations that govern epigenetic development. Neither sperm nor ovum would be found to contain an embryo, though within each would be discerned the hereditary determinants of the species, and jointly sperm and egg would provide the continuity of life between generations, a con-

* This essay is based upon three essays by the author in *Forerunners of Darwin, 1745–1859* and upon companion essays by Arthur O. Lovejoy on Buffon and by Lester G. Crocker on Diderot, contained in the same volume (B. Glass, O. Temkin, and W. L. Straus, Jr., eds., Baltimore, The Johns Hopkins Press, 1959).

tinuity without which species could have neither that constancy necessary to their status as real entities nor that store of hereditary variations upon which their evolution depends.

Observation shows that the individuals of a species differ among themselves in addition to differing from individuals of other species. How, then, distinguish the interspecific from the intraspecific differences? Are the former more real than the latter? Is there a more unbridgeable gap in the Continuity of Nature between species than between individuals belonging to the same species, even though the latter may be distinguished as members of different races?

John Ray grappled with this problem in his attempt to bring order into the classification of plants and animals. First of all, he recognized the Principle of Continuity.

> Nature [he wrote in 1682] as the saying goes, makes no jumps and passes from extreme to extreme only through a mean. She always produces species intermediate between lower and higher types, species of doubtful classification linking one type with another and having something in common with both—as for example the so-called zoophytes between plants and animals.[1]

But the species nevertheless retain their individuality, and do not constantly flow into one another. Differences between individuals of a species indeed exist—consider, he suggested, the great difference that often distinguishes a male from a female of the same species, a bull from a cow, a man from a woman. They are nevertheless of the same species because they share a common descent. Filiation constitutes the surest criterion of a species ("non aliud certius indicium convenientiae specificae est"). Thus, among plants, "one species does not grow from the seed of another species."[2]

One must note that acceptance of the Principle of Continuity by no means forced Ray, or other natural philosophers of the seventeenth and eighteenth centuries, to accept the transformation of species. Quite the contrary! The species was constant, so long as individuals of common descent, no matter how different they might be in certain respects, interbred and produced offspring true to the type of the species. The *type* was God-given; like the Platonic idea, it was more real than the variations from it. Individuals, being at best imperfect representations of the type, manifest deviations and variations from the perfect type, but these are of no permanent consequence in the unbroken filiation of the species. Rarely, transmutations of species might arise by degeneration, as in an instance accepted by Ray of the degeneration of cauliflower into ordinary cabbage; but such cases always involved closely related forms that were perhaps not truly distinct species.

Linnaeus, in the *Systema Naturae* (1736) and other early works, accepted the foregoing conception of the nature of species without troubling himself greatly about the problem of variation—a mere vexatious complication in the way of the great task of classification. The fixity of species was adopted without question. The *Fundamenta Botanica* of 1736 already contained the famous dictum: *Species tot sunt diversae quot diversas formas ab initio creavit infinitum Ens;* and over and over through his works up to 1751 there recurs the expression *nullae species novae.* To what extent did this position stem from that of Ray? Or was it adopted because of Linnaeus' rejection of spontaneous generation and alignment with the ovists? At all events, he reduced the great majority of Ray's 18,000 entries to the status of varieties and named only 7,300 *true* species. In the *Philosophia Botanica* of 1751 Linnaeus makes clear the basis of the distinction. Species were not only those entities created in the beginning, but individuals of a species "multiply and produce, according to the laws of generation, forms always like themselves. This is why there are just so many species as there exist today diverse forms of structures." Varieties, on the other hand, were simply "plants of the same species modified by whatsoever occasional cause," such as "the climate, sun, warmth, the winds, etc." They relate only to "stature, color, taste, odor," and upon the return of the plant to its original environment, they revert to type.

Although the first position taken by Buffon in regard to the nature of species was violently opposed to that of Linnaeus, it likewise was based on Leibniz' Principle of Continuity. In the first volume of the *Histoire Naturelle* (1749), Buffon insisted that species were constructs of the human mind.

> But Nature proceeds by unknown gradations, and consequently cannot wholly lend herself to these divisions—passing, as she does, from one species to another species, and often from one genus to another genus, by imperceptible shadings; so that there will be found a great number of intermediate species and

[1] Ray, J., *Methodus plantarum nova*, Preface, London, 1682.

[2] Ray, J., *Historia plantarum generalis*, London, 1686.

of objects belonging half in one class and half in another. . . . In general, the more one increases the number of one's divisions, in the case of natural products, the nearer one comes to the truth; since in reality individuals alone exist in nature, while genera, orders, classes, exist only in our imagination.[3]

But this was essentially a philosophical position, and deeper acquaintance with certain hard biological facts soon led Buffon to change his mind. In his second volume, published in the very same year as the first, the troublesome problem of the inability to hybridize was met—and Buffon rapidly shifted to a conception of the species as a real, constant and invariable entity. His own words set forth the matter admirably:

We should regard two animals as belonging to the same species if, by means of copulation, they can perpetuate themselves and preserve the likeness of the species; and we should regard them as belonging to different species if they are incapable of producing progeny by the same means. Thus the fox will be known to be a different species from the dog, if it proves to be a fact that from the mating of a male and a female of these two kinds of animals no offspring is born; and even if there should result a hybrid offspring, a sort of mule, this would suffice to prove that fox and dog are not of the same species —inasmuch as this mule would be sterile (*ne produirait rien*). For we have assumed that, in order that a species might be constituted, there was necessary a continuous, perpetual and unvarying reproduction (*une production continue, perpétuelle, invariable*)—similar, in a word, to that of the other animals.[4]

Buffon has here aligned himself with Ray and Linnaeus, and established the inability to hybridize successfully as the basic criterion of the species.

Buffon's consideration, first, of the separability of species, and second, of the unity of plan and the presence of numerous homologies of structure in similar animals led him in the fourth volume of the *Histoire Naturelle* (1753) to advance a clearly stated theory of the transformation of species:

Not only the ass and the horse, but also man, the apes, the quadrupeds, and all the animals, might be regarded as constituting but a single family. . . . If it were admitted that the ass is of the family of the horse, and differs from the horse only because it has varied from the original form, one could equally well say that the ape is of the family of man, that he is a degenerate (*dégénéré*) man, that man and ape have a common origin; that, in fact, all the families, among plants as well as animals, have come from a single stock; and that all animals are descended from a single animal, from which have sprung in the course of time, as a result of progress or of degeneration, all the other races of animals. For if it were once shown that we are justified in establishing these families; if it were granted that among animals and plants there has been (I do not say several species) but even a single one, which has been produced in the course of direct descent from another species; if, for example, it were true that the ass is but a degeneration from the horse—then there would no longer be any limit to the power of nature, and we should not be wrong in supposing that, with sufficient time, she has been able from a single being to derive all the other organized beings.[5]

This theory, however, he rejected, as Lovejoy points out, on three grounds: (1) no new species were known to have appeared; (2) there are no descendants of those intermediate types which must once have existed, but only the extreme types remain; and (3) the infertility of hybrids constitutes an absolute barrier. In 1755, in the fifth volume, we still find him saying that "animal species are all separated from one another by an interval which Nature cannot overstep."[6]

Buffon, nevertheless, was keenly aware of the great variability of animals. Much of this he attributed to the influences of climate, but he was led to wonder more than once whether species cannot change like varieties, inasmuch as every genus contains species which closely resemble each other, like the varieties within a species. The end of this line of reasoning on the part of Buffon was to reduce the number of true, original species to a very few—only thirty-eight among all quadrupeds, for example. Within each such comprehensive "species"—equivalent to conventional genera or even families—there might be very extensive transformations. This conclusion was reinforced in his mind by further studies of hybridization, reported in 1776. The occasional fertility of mules, and the production of hybrids between goats and sheep (fictitious), dogs and wolves, and canaries and goldfinches, all show that sterility is a matter of degree. The relative sterility of hybrids leaves something of the criterion of species but again raises questions of transformism. "Is the dog nearer to the wolf than to the fox or the jackal?" How determine except by innumerable attempts at cross-breeding? Have not races in general arisen in a similar way, because of the origin of some inability to mate with the original species? "Were all the species

[3] Buffon, L. L. de, *Histoire naturelle* **1**: 13, 38, Paris, 1749.

[4] Buffon, L. L. de, *Histoire naturelle* **2**: 10, Paris, 1749.

[5] Buffon, L. L. de, *Histoire naturelle* **4**: 383, Paris, 1753.

[6] Buffon, L. L. de, *Histoire naturelle* **5**: 59, Paris, 1755.

of animals formerly what they are today? Has their number not increased, or rather, diminished?" [7] The sense of his last question is the following: Would hybridization merge originally distinct species, or would the origin of sterility barriers split one species into several? Evidently Buffon remained uncertain. It was easier to dispose of the problem by enlarging the limits of the "true" species until all these vexatious questions of variation and hybridization were encompassed within the bounds of each species. To do this was in fact to beg the question. True, it enabled Buffon to say: I am not a believer in the transformation of species—I have merely raised the question and have rejected the theory on the basis of the evidence. In actuality, however, by any acceptable, either contemporary or modern, identification of actual species, Buffon would have to be set down on the side of transformism.

It is a striking coincidence that Linnaeus, also by examining the problem of hybrids, was led to precisely the same final conclusion. In 1742 a student brought Linnaeus a specimen of a flower, gathered near Uppsala, and resembling the common toadflax *Linaria* in all respects except that its corolla was a simple tube with evenly matched divisions into five petals at the mouth, whereas *Linaria* has an irregular tubular flower like a snapdragon's. Linnaeus called the new form *Peloria*, and after a study of specimens grown in his garden, and found to breed true, he concluded that it must be ranked as a new species and that it had arisen as a hybrid. Unfortunately for the clarity of his own thinking, instead of attempting to cross it with *Linaria* so as to study the inheritance of the mutant form—for that is what it was—Linnaeus and his students excitedly proceeded to hunt for other new species that had arisen through hybridization. Identification was strictly on the basis of the possession of characteristics intermediate between two purported parent species. Some of their numerous finds were probably genuine hybrids, but most of them were dubious. Only one hybrid was actually reported by Linnaeus to have been produced in his own garden by artificial hybridization. This was a *Tragopogon* produced in 1757, of which more later.

The effect of these studies was to shake Linnaeus' belief in the fixity of species, and even to make him conjecture that climate and soil might lead to the production of one species from another. In 1762 Linnaeus suggested that the creative act of God had stopped with providing the common source of each genus, and that diversification within these original groups had led to the production of species. In 1766 he omitted from the final edition of the *Systema Naturae* the famous dictum, *nullae species novae*. Finally, in 1779 he expressed the view that "species are the work of time," and that one of the great scientific enterprises of the future would consist in demonstrating that truth. In the end, therefore, the great originator of the concept of the fixity of species, by studying hybridization, came to believe in the evolution of the smaller systematic categories, of the species as he knew species, and maybe of the genera. Nevertheless, like Buffon, he held to the end the view that the original Creation was of a multitude of forms, distinct then and forever. Linnaeus' "original stocks" and Buffon's ultimate "species" are conceptually equivalent. The sole difference was a matter of terminology, since Linnaeus continued to call the hybrid plant forms "species" while Buffon refused to apply that term to the varieties of animals composing his own enlarged "species."

It may be surprising to realize that in the eighteenth century Linnaeus was recognized among his contemporaries as a leading proponent of the transformation of species. This is clear from a memoir written by the French botanist Adanson in 1772: "Examen de la question, si les espèces changent parmi les plantes; Nouvelles Expériences tentées à ce subjet." [8] This remarkable paper is concerned wholly with the refutation of Linnaeus' views regarding the origin of new species. Referring to Marchant's statement about the significance of his mutant *Mercurialis*, Adanson wrote:

> This opinion remained forgotten until the year 1744, when M. Linnaeus after having regarded species as constant in 1740, commenced to doubt it, and even to believe in the production of new species when speaking of the plant he called *Peloria;* and after having cited the two examples of M. Marchant, he enumerated six others upon which we will now report.

Adanson thereupon proceeded to describe his own experimental tests of these reputed species, and to demolish their claims to any such status.

Michel Adanson, from a long botanical experience in tropical Africa, felt strongly that the

[7] Buffon, L. L. de, *Histoire naturelle*, Suppl., **3**: 20, Paris, 1776.

[8] Adanson, M., *Mém. Acad. Roy. Sci.*, 31–48, 1769.

distinction between varieties and species was one most difficult to make. He deplored Linnaeus' exclusion of all varieties, and thus was admittedly predisposed to accept an evolutionary view; but he strongly doubted that Linnaeus' *Peloria* and the other reputed new species were really hybrids. Perhaps they were simply previously undiscovered varieties. Following the discovery of a strawberry (*Fragaria*) having an entire leaf instead of the typical condition of three leaflets, and the claim by the younger Duchesne (one of its discoverers) that it was a new species, Adanson obtained the new variety for propagation in the gardens of the Jardin des Plantes. He also bred here Linnaeus' *Peloria*, the *Mercurialis* of Marchant, Vaillant's Miracle, or Smyrna, wheat, and a variety of barley with 4-ranked instead of 2-ranked ears, which Adanson had found himself. By painstaking experiments over the space of seven years Adanson convinced himself that every case put to the test revealed itself as no new species, but was instead a mutant variety, as we would say today. Each case was a "*monstre par excès*" or a "*monstre par défaut*." For example, the abnormal *Mercurialis* could be crossed with normal *Mercurialis* and in succeeding generations, even to the fifth, yielded only ordinary *Mercurialis* plants; but attempts to cross the mutant with other species which were suspected as parents, e.g., with mignonette or flax, proved entirely sterile. The same result was obtained with the *Peloria* and the strawberry, the barley and the wheat. The two latter, in fact, did not breed entirely true to type, but showed some tendency to revert to normal. As we would say today, these mutants showed incomplete penetrance. At all events, Adanson was entirely correct in ruling out a hybrid origin and in maintaining that these novel types were simply mutants (*monstres*) of the regular species. It is a pity that, in the case of the recessive *Mercurialis*, he did not recover in the later generations the mutant with its dissected leaves, or we might, from so careful a worker, have obtained an anticipation of Mendel's Law of Segregation; but the crosses were not highly productive, and Adanson must have been satisfied with rather small progenies.

Adanson's final conclusion was that Linnaeus was wrong. ". . . The transmutation of species has not taken place among the plants, no more than in animals. . . ." Further, ". . . these monstrosities and variations have a certain latitude, necessary without doubt for the equilibrium of things, after which they return into the harmonious order preestablished by the wisdom of the Creator."

Another crushing blow had been dealt even earlier to Linnaeus' theory of the origin of new species through hybridization. This was through the work of Joseph Gottlieb Koelreuter, beginning in 1761 and continuing through 1765, on authentic species hybrids among plants. Koelreuter made the first critical improvements in the production of plant hybrids, by making artificial transfers of pollen to the stigmas of flowers and by taking pains to exclude insects from access to them. The studies of his first hybrid tobacco plant (*Nicotiana*) showed that the hybrid plants were regularly intermediate in type between the parent species, and that while vigorous in growth, they failed to form pollen and hence were sterile. He called them "muleplants." Back-crosses could be carried out, however, if the hybrid was pollinated by either of the parent species; and from these back-crosses Koelreuter discerned a tendency to revert to the type of the original species used as back-cross parent. He therefore rejected Linnaeus' new "hybrid" species. They could not be true-breeding hybrids, as Linnaeus thought, for hybrids are sterile except in back-crosses, and then they tend to revert to the original forms. About Linnaeus' one artificial hybrid, the *Tragopogon*, Koelreuter also remained dubious. Having received it from Linnaeus and grown it in his gardens in St. Petersburg, Koelreuter concluded, on the basis of a mistaken theory of his own, that it had a tincture of self-fertilization in its origin, and was only a "half-hybrid."

Koelreuter's further studies in hybridization demonstrated that only closely related species may be crossed at all, and not always even these, whereas Linnaeus had conjectured wide hybridizations in the origin of some of his supposed new species. Moreover, the back-crosses of hybrids and the occasional fertile self-fertilizations which were possible with some of the later species hybrids made by Koelreuter demonstrated that, contrary to Linnaeus' views, hybrids do not breed true at all. They segregated numerous varieties and tended to revert to the parental species. The self-fertility of some of these hybrids, it may be pointed out, was destructive of Buffon's belief that the sterility of hybrids forms an impassable gap between species. Of course, it might be claimed that the forms which had been crossed were not true species, but this solution of the dilemma led directly to the enlargement of the species until it engulfed the entire genus or even

the entire family. Few have been willing to follow Buffon down this road. But to accept the alternative was more frankly to admit the probability that species may become altered by intermingling with other species. If so, what keeps the species in nature breeding true to type? It seems curious that Koelreuter himself evaded the issue of the nature of species and ignored the light thrown upon it by his own experiments. Having demolished Linnaeus' theory of new species through hybridization, and thus having saved the dogma of the constancy of species from the hands of its faithless creator, he failed to see that he had in truth opened Pandora's box, since henceforth no one would ever be able to distinguish species from races and varieties by any single, simple criterion.

The influence of Koelreuter upon the development of evolutionary theory was thus a decisive factor in the eighteenth century. For a long time to come, to the time of Darwin and Mendel and beyond, the problem of species hybrids would monopolize attention. From Koelreuter through Knight, Herbert, and Gärtner to Naudin and Nägeli, plant hybridizers were so preoccupied with species hybrids and the seeming insolubility of the problem of species in relation to hereditary variation that they failed to comprehend the work of Gregor Mendel when it appeared, just as some of them had failed to appreciate the significance of dominance and simple ratios which appeared in their own experiments. Yet Mendel too received his primary interest in this subject as much from Koelreuter as from Darwin. Who would have supposed that the study of simple variations, the *monstres* of Adanson, would one day throw more light on the nature of the origin of species than all the ten thousand crosses and three hundred and fifty species hybrids so painstakingly produced and catalogued by Gärtner? Yet it was to be so.

EPIGENESIS AND EVOLUTION

Since the doctrine of preformation, held by almost all natural philosophers of the eighteenth century, clearly excluded the idea of the origin of species except by hybridization, one must look for believers in evolution principally among the dwindling adherents of epigenesis. Among these was Buffon, but, as we have seen, his conception of the nature of species tended to preclude a clear and open commitment to the origin of species either by hybridization or by transformation. Casper Friedrich Wolff, whose demonstration of epigenetic development of the blood vessels and intestine in the embryo chick (1759) marked a momentary resurgence of epigenesis, was rapidly set down as an impetuous upstart by the magisterial von Haller; and any real appreciation of the merit of Wolff's work therefore belongs to the nineteenth rather than to the eighteenth century. Only in the work of Pierre Louis Moreau de Maupertuis can we find a consistent development of biological ideas leading from epigenesis and the nature of heredity to considerations about the origin of species; and these ideas had great influence upon both Buffon and Diderot, and presented the most redoubtable difficulties to Charles Bonnet's defense of preformation.

Maupertuis' disbelief in preformation stemmed from his conviction that heredity is biparental. In the *Vénus Physique* (1745), he demonstrated the fact by means of a remarkable study of the transmission of polydactyly in a Berlin family named Ruhe. This seems to be the first careful examination ever made of the inheritance of a human trait. Both the affected and unaffected members of the family were enumerated, and over the span of four generations transmission through both affected male and female members of the family was documented. The data are sufficient to enable a modern geneticist to set forth the pedigree, establish that there was an unbroken dominant autosomal transmission of the trait, that affected persons produced half affected and half unaffected offspring, and that polydactyly is variable in degree. [The last-mentioned fact led Maupertuis to an erroneous conclusion that the marriage of a fully hexadactylous person with a pentadactylous one would lead to a diminution in the degree of expression of the trait, which could therefore be maintained in full strength only by marriages of two hexadactylous persons.] Maupertuis furthermore carried out a mathematical calculation of the probability that the occurrence of polydactyly in four successive generations of a family was not hereditary but was merely a coincidence of its occurrence in the general population. This application of the principle of the coincidence of independent probabilities made fifty years before its statement by Laplace, is surely the first application of the mathematics of probability to genetic phenomena. Having thus assured himself that polydactyly is hereditary and is transmissible through either a male or a female parent, Maupertuis affirmed that this conclusion totally destroyed the reasonableness of the preforma-

tionist view, whether ovist or animalculist. How, if the embryo is preformed either in the egg or in the sperm, can a trait be transmitted equally well from either parent?

A similar family study of human polydactyly was reported by Réaumur in 1751,[9] but seemingly never reached the attention of Maupertuis, who at that time became embroiled in a bitter quarrel with Voltaire which eventually led to the loss of his reputation and his withdrawal from public life. The second, or Kelleia, pedigree attained greater note than Maupertuis' study of the Ruhe family, however, and became the basis of a lengthy consideration of its significance for the doctrine of preformation by Bonnet. Later, when Bonnet read of Maupertuis' study, he added an extended footnote in the *Considérations sur les corps organisées* on the Ruhe family, and concluded: "It seems, then, that one must recognize that polydactyly is transmitted or appears to be transmitted by the one sex or the other."[10] But Bonnet then proceeded to argue ingeniously that this would not exclude the preformation of the germ in the egg. Just as in the cross between a mare and a jackass the seminal fluid of the latter modifies the growth of the germ (which nevertheless remains that of a true horse) in such a way that the ears grow longer, the natural fertility is impaired, and the modified larynx gives forth a bray, so might the seminal fluid of a six-fingered male modify the germ in the egg of a five-fingered female, and change the course of development although not the germ itself. Bonnet seemed oblivious to the fact that the modification is thenceforth transmitted through indefinite generations. How might this be, if the germ itself is not altered? In the case of the mule, its sterility conveniently precluded any test; but in the case of human polydactyly the issue cannot be so lightly set aside. As for transmission of polydactyly through the female, Bonnet was inclined to consider it a product of abnormal intra-uterine conditions which modify the normal germ into an abnormal one. He thus attempted to exclude polydactyly from the constitution of the germ itself. But in doing so, he missed altogether the force of Maupertuis' reasoning on the basis of probability and evaded the real problem posed by the heritability of polydactyly over an indefinite succession of generations.

Maupertuis' consideration of hereditary phenomena led him to postulate that the foetus is formed through the combination of particles derived in pairs, one from the father, the other from the mother, each pair of particles determining a certain characteristic part of the body. These organic particles were endowed with a sort of organic memory of their history in antecedent generations as well as an affinity leading to the pairing of the corresponding particles derived from the two parents. Much ridiculed by Voltaire, and vigorously combatted by Bonnet, this theory greatly appealed to Buffon, who presumably founded upon it his own theory of organic particles as the basis of heredity and development. Diderot, however, as Crocker has pointed out, was repelled by the attribution to organic matter of qualities resembling intelligence—in Maupertuis' words, "akin to what in us we term desire, aversion, memory." Was this not to separate organic matter from the inanimate world? Today, however, we must recognize Maupertuis' startling prevision, not only of an essentially particulate nature of heredity, prefiguring the genes, but also of the essential behavior of the hereditary material, which in its properties of replication and synapsis of alleles indeed possesses something on the chemical level very akin to memory and affinity on the level of the organism.

Maupertuis' studies, including some breeding experiments which he conducted with dogs in order to determine whether supernumerary digits and various colors were inherited biparentally, like polydactyly in man, led him to a theory of the origin of species. Is the supernumerary fifth digit so frequently found on the hind feet of dogs really supernumerary, he asked, or is it a vestige of an earlier condition when dogs had five toes on each hind foot as they do on each fore foot? Losses of structures can be inherited just as much as superfluities. Losses of hereditary particles might produce losses of parts (*monstres par défaut*) and superfluous particles, when particles united by more than pairs, might produce supernumerary parts (*monstres par excès*). Moreover, what should prevent, he added, other accidental assemblages of the hereditary particles, involving resemblance to the ancestor rather than the parent, or even "a total forgetfulness of the previous situation"—in modern terms, a muta-

[9] Réaumur, R. A. F. de, *L'art de faire eclorre et d'enlever en toute saison des oiseaux domestiques des toutes especes*, 2 v., 2nd ed., Paris, 1751.

[10] Bonnet, C., *Considérations sur les corps organisées*, Part II, Chap. VIII, CCCLV, Neuchatel, 1779.

tion.[11] Since Maupertuis failed to distinguish between a simple hereditary difference and the multiple differences between species, and—like Linnaeus in his own time and Hugo de Vries a century and a half later—regarded a mutant form occurring in nature as a novel species, it is easy to follow the train of his reasoning. If negroes can by mutation produce "whites," as Maupertuis regarded the famous albino negroes who had first excited his interest in these problems, then racial, or species, differences can arise abruptly by the alteration of the hereditary particles. The evidence was clear from the artificial breeds of domestic animals. Just as for Charles Darwin a century later, it was in particular the pigeons that clinched the argument:

> Nature contains the basis of all these variations: but chance or art brings them out. It is thus that those whose industry is applied to satisfying the taste of the curious are, so to say, creators of new species. We see appearing races of dogs, pigeons, canaries, which did not at all exist in Nature before. These were to begin with only fortuitous individuals; art and the repeated generations have made species of them. The famous Lyonnes [Lyonnet] every year created some new species, and destroyed that which was no longer in fashion. He corrects the forms and varies the colors: he has invented the species of the harlequin, the mopse, etc.[12]

If the ingenuity of man can produce species, why cannot nature do the same, either by "fortuitous combinations of the particles of the seminal fluids, or effects of combining powers too potent or too weak among the particles" or by the action of the environment, such as the effect of climate or nutrition, on the hereditary particles?[13] Suggesting with some reserve that the alterations of the particles might not be the sole cause of new species, but that the inheritance of the effects of climate and nutrition upon them might be worthy of investigation, Maupertuis in this instance anticipated Lamarck and Erasmus Darwin, and at the same time adopted a more cautious, experimental attitude toward the question than either of them.

The action of natural selection was clearly set forth in the *Essai de Cosmologie* (1750), and the generally deleterious character of new mutant "species" in the *Vénus Physique*. Some new forms, however, must survive under the influence of geographical isolation. The dark-skinned peoples inhabit the tropics, the white-skinned ones the temperate zones. Differences in stature are also to be found characterizing different peoples; even giant and dwarf races occur. To sum up:

> Could we not explain in this way [mutation] how from two individuals alone the multiplication of the most dissimilar species might have resulted? Their origin would be owing only to certain fortuitous products, in which the elementary particles failed to retain the order they possessed in the father and mother animals; each degree of error would have created a new species; and by dint of repeated divergences there would have come about the infinite diversity of animals that we see today; which will perhaps still increase with time, but to which the passage of centuries will perhaps bring only imperceptible additions.[14]

This brilliant reasoning, although acclaimed by Diderot, had no lasting effect. The combination of Voltaire's ridicule and the strength of preconceived ideas prevailed, and by 1775 preformation seemed firmly and permanently established. "Nullae species novae"—no spontaneous generation, no transformation, no real hereditary change. It would take a new generation, the generation of Lamarck, and after that another, the generation of von Baer, before the transformation of species could be seriously reconsidered. And still beyond that time, a century would lapse ere the element of truth embodied alike in the preformation theory and the epigenetic view of development would become reconciled in a higher synthesis, the genetic theory of development. And it would take that long, too, for the genetic analysis of variation to make clear the problem of hybrid sterility, to establish genetic mutation as the source of hereditary variation, and fully to characterize the species in dynamic, evolutionary terms.

[11] Maupertuis, P. L. M. de, *Système de la nature* **42**, 1751 [*Œuvres* **2**, Lyon, 1756].

[12] Maupertuis, P. L. M. de, *Vénus physique*, Part II, Chap. III, La Haye, 1745.

[13] Maupertuis, P. L. M. de, *Vénus physique*, Part II, Chap. VII, La Haye, 1745.

[14] Maupertuis, P. L. M. de, *Système de la nature* **45**, 1751 [*Œuvres* **2**, Lyon, 1756].

ECOLOGY IN THE LONG MANUSCRIPT VERSION OF DARWIN'S *ORIGIN OF SPECIES* AND LINNAEUS' *OECONOMY OF NATURE*

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In the midst of celebrations of the centennial of the public announcement of Charles Darwin's theory of evolution by natural selection, it might seem inappropriate to turn our attention to discuss Darwin's views on what was soon to be christened ecology.[1] Although Darwin's expression of his ecological ideas might appear to be only incidental to his arguments for the reality of evolution and for the importance of natural selection as a mechanism of evolution, yet full understanding of the action of natural selection requires analysis of the relations of plants and animals to each other and to their environment, and study of the "conditions of the struggle for existence" leads directly into ecology. And thus ecology is an indispensable adjunct to the study of evolution. This paper will examine Darwin's ecological views, the relation of these views to his theory of evolution and their probable sources in his experience and his reading.

Darwin's influence on the history of ecology resulted in the very christening of the science itself by Ernst Haeckel who once explained that "By ecology we mean the body of knowledge concerning the economy of nature" and who concluded "in a word, ecology is the study of all those complex interrelationships referred to by Darwin as the conditions of the struggle for existence." [2]

When we turn to look for the historical source material revealing Darwin's thought, we find that beside his abundant published work, there is also unpublished material of great interest. There is much information in Darwin's surviving manuscripts, notebooks, scientific papers, and annotated volumes of his library. One hundred and fifty volumes and packets of his papers are available to scholars at the Cambridge University Library thanks to the generosity of the Darwin family and the Pilgrim Trust. Meanwhile the bulk of his scientific library has been shelved at the Darwin museum at Down House in Kent.

As far as Darwin's ecological ideas are concerned there are three sources which need special mention. One is the series of copious marginalia in the books in Darwin's own library, such as in numerous editions of Charles Lyell's *Principles of Geology*. Another is the series of small leather-bound notebooks which Darwin kept to list dates and titles of his reading from 1838 to 1860. The major source is none other than the great manuscript of Darwin's big book, whose composition was cut short by the arrival of Wallace's historic letter on his theory of evolution. This is the work which Darwin named "Natural Selection" when he discussed it in the letter to Asa Gray outlining his views on evolution—the letter which was read in excerpts along with Wallace's Sketch at the famous meeting of the Linnean Society held on the first of July, 1858.[3] If we count Darwin's 1842 sketch of his theory as version I of his species book, and the 1884 essay as version

[1] Read at the meeting of the History of Science Society, Washington, D. C., December, 1958. The research for this paper was made possible by a research leave and travel funds for 1957 granted by the Graduate School Research Committee of the University of Wisconsin and supplemented for 1958 by a travel grant from the American Philosophical Society. It is a pleasure to thank the Cambridge University library for permission to have Charles Darwin's long manuscript version of the *Origin of Species* microfilmed and Mr. H. R. Creswick, university Librarian and Mr. Gautrey of the Anderson Room for their hospitable assistance.

[2] The term "ecology" was publicly introduced in Haeckel's *Generelle Morphologie der Organismen*. . . . 2 vols., Berlin, 1866, see R. C. Stauffer, Haeckel, Darwin, and ecology, *Quart. Rev. Biology* **32**: 138–144, 1957. The quotation is translated from Haeckel's inaugural lecture delivered at Jena in 1869 and published in his *Gesammelte populäre Vorträge aus dem Gebiete der Entwickelungslehre* **2**: 17, Bonn, 1879. The translation is quoted from W. C. Allee, *et al., Principles of animal ecology*, v, Philadelphia, Saunders, 1949. As Paul H. Oehser has noted in his recent article on: The word "ecology," *Science* **129**: 992, 1959, Thoreau had earlier used the term "ecology" in a private letter of January 1, 1858.

[3] Charles Darwin and Alfred Wallace, On the tendency of species to form varieties; and on the perpetuation of varieties and species by means of selection, *Jour. of the Proc. of the Linnean Society* (Zoology), **3**: 51, 1858.

II,[4] this manuscript on Natural Selection is version III. Version IV, an abstract of version III, was the *Origin* as published in 1859.

This manuscript of "Natural Selection" deserves more attention than it has so far received. During the two years from May, 1856, to the day in June, 1858, when Darwin received Wallace's letter from the East Indies, Darwin had covered in revised draft about 70 per cent of the topics later included in the *Origin of Species*, and his manuscript was probably already more than twice as long as the *Origin of Species*. Only four of the chapters later appearing in the published version remained undrafted; these were on the Imperfection of the Geological Record, On the Geological Succession of Organic Beings, on Morphology, Embryology, and Rudimentary Organs, and the Recapitulation and Conclusion; eleven chapters were written out. As Darwin tells us in his *Autobiography*, the manuscript is "on a scale three or four times as extensive"[5] as the later "abstract" which was published in 1859. Here in the manuscript are many corroborative details and examples which Darwin was later forced to omit. Also in the manuscript is the long series of books and articles which Darwin cited in his abundant notes. For here in his conscientious way Darwin listed the writers whose information and ideas he had found most valuable. These notes Darwin was also too rushed to include in the published version.

From these writings of Darwin, published and unpublished, what ecological concepts can be singled out? Darwin's fundamental ecological insight was that the natural world forms an organized interrelated system. This system may be regarded from various points of view. One point of view emphasizes its social structure: the natural world regarded as a polity, a republic of social groups. Another point of view emphasizes the dynamic relations between members: the world as an economic system.

The whole interrelated system of plants and animals in their physical environment Darwin designated by two phrases which he used interchangeably. Sometimes he spoke of the "polity of nature" and sometimes of the "economy of nature." It was for the study of this economy of nature that Haeckel invented the term ecology.

Darwin described the economy of nature as a "web of life" involving a complex network of interrelations. He points out that the survival of the mistletoe involves not only the availability of the host tree, but also the activity of insects for fertilization of the flowers and of birds for spread of seeds as well.[6] Similarly in Darwin's example of the cats to clover chain, if the number of cats goes up, the number of field mice goes down. Then the number of bumble bees goes up, and the amount of red clover goes up. Decrease in the number of cats would lead to the opposite end results.[7]

Other samples of this "web of complex relations" led Darwin to the general observation that: "in the long-run the forces are so nicely balanced that the face of nature remains uniform for long periods."[8] We can say that on the whole the economy of nature is a system in dynamic equilibrium.

Recovery of the balance of nature may take a long time. Darwin noted the striking "change of vegetation when a N. American forest has been burnt or cut-down & then left to nature."[9] Yet despite the great initial difference in vegetation after a succession of stages the climax is the reappearance of the original kind of forest. As Darwin expressed it:

> In these cases, the trees reassume in the course of ages the same beautiful variety in the same exact proportions as in the surrounding virgin forest: this has been noted in many parts of the world, as over the ancient American ruins in Central & North America.[10]

The forces in balance are the forces of propagation and destruction: superfecundity and the various checks to increase in numbers. These subsidiary aspects of the economy of nature Darwin studied very thoroughly. He discussed a number of striking examples of the tendency to

[4] *The foundations of the origin of species: two essays written in 1842 and 1844 by Charles Darwin*, ed. Francis Darwin, Cambridge, University Press, 1909; republished in Charles Darwin and Alfred Russel Wallace, *Evolution by natural selection*, Cambridge, University Press, 1958.

[5] *The autobiography of Charles Darwin*, ed. Nora Barlow, 121, London, Collins, 1958.

[6] *The origin of species: by Charles Darwin. A variorum text*, ed. Morse Peckham, Introd. Sent. 25, Philadelphia, Univ. of Pennsylvania Press, 1959. Peckham introduces a reference system based on chapter number and sentence number in the first edition, see pp. 28–31.

[7] *Ibid.*, Ch. III, Sent. 115–123.

[8] *Ibid.*, Ch. III, Sent. 113.

[9] Cambridge University Library Darwin Manuscripts, **10.1**. (Chapter 5 of *The origin of species* as originally planned, "The struggle for existence"), fol. 50. This whole manuscript merits publication, and I have already transcribed and edited part of it.

[10] *Ibid.*, fol. 51–52.

increase, including the spread of wild horses on the South American pampas. In Paraguay this spread was opposed by the check to increase caused by "a certain fly there which lays its eggs in the navel of the newly born young." [11] These checks to increase Darwin also called the "Police of Nature." These checks are the very agents of natural selection.

Another subsidiary concept in Darwin's manuscript is that of "places in the polity of nature." These places are what Charles Elton has called "niches." [12] From the ecological point of view, the struggle for existence is a struggle for a place in the economy of nature. Successful immigration, Darwin argued, shows

> that in the natural polity of each land there were places open, which could be filled by other beings more perfect, not by any ideal standard but by actual proof, in relation to the previous inhabitants & to the climatal conditions of the land.[13]

He further wrote that:

> the selection of new specific forms is far more intimately related to the surrounding organic beings, amongst which each has to struggle for existence, & to seize on & occupy by selected changes in its structure any vacant place in the economy of nature.[14]

In the evolution of Darwin's thought, the germ of this idea of places in the economy of nature can be traced as far back as the marginalia he wrote in his copy of the 1837 edition of Lyell's *Principles of Geology*. Here in answer to Lyell's rhetorical question: if evolution has produced higher forms from simpler ones why do we find "still so many beings of the simplest structure?" Darwin commented: "Because there were localities fitter for simplest animals as well as the most complex, therefore some remained simple if not created." [15]

In a similar vein in 1841 in the third volume of the *Zoology of the Voyage of H. M. S. 'Beagle,'* Darwin wrote in regard to the mockingbirds of the Galapagos Islands that: "The habits of these three species are similar and they evidently replace each other in the natural economy of the different islands." [16] And in 1842 in discussing coral reefs, he wrote that "no station capable of supporting life is lost . . . there is a struggle for each station between the different orders of nature." [17]

Associated with this concept is the principle of divergence which Darwin afterwards stressed in the letter to Asa Gray, read at the famous meeting of the Linnean Society. In his manuscript Darwin explained this principle by saying:

> in any country a far greater number of individuals descended from the same parents can be supported when greatly modified in different ways, in habit, constitution & structure so as to fill as many places as possible in the polity of nature.[18]

He illustrated this principle of divergence by his comments on the island of Madeira and the Galapagos Islands:

> What a contrast [to Madeira] is presented by the Galapagos Islands, situated in a most temperate climate, without any storms to blow birds from the mainland, which is nearly twice as far off: in this considerably larger group we have 26 land-birds of which 25 are endemic or peculiar to the Archipelago! Of these 26 species, 8 belong to one endemic genus Geospiza & five others belong to three subgenera closely allied to Geospiza: there are three closely allied mocking thrushes, & two tyrant-flycatchers; so that I imagine that there were only 14, perhaps only 11 original strong colonists which arrived at different periods, & which had to fill the places in the economy of nature, occupied by 20 birds in the very much smaller island of Madeira; hence I suppose that nearly all the birds had to be modified, I may say improved by selection in order to fill as perfectly as possible their new places.[19]

We can now see better what led Darwin to say that "the existence, therefore, of an unoccupied or not perfectly occupied place is an all important element in the action of natural selection." [20]

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[11] *Ibid.*, fol. 19.

[12] Charles Elton, *Animal ecology*, 64, N. Y., Macmillan 1927.

[13] Cambridge University Library, Darwin Mss. **10.2** (Chap. 6 "On Natural Selection") fol. 11. There are repeated references to "places in the economy of nature" throughout this chapter.

[14] *Ibid.*, **14** (unnumbered chapter on geographical distribution) fol. 23 of Darwin holograph = fol. 21 of fair copy.

[15] Charles Darwin's Library, bequeathed to Cambridge University, in part currently shelved in the Darwin Museum at Down House, Downe, Kent. Darwin wrote this marginal comment on page 374 of volume II of his copy of the 5th edition of Charles Lyell's *Principles*, London, 1837. Darwin owned copies of the 1st edition (1830–1833), 5th ed. (1837), 6th ed. (1840), 7th ed. (1847), 9th ed. (1853), 10th ed. (1867–1868), and 11th ed. (1872), see H. W. Rutherford, *Catalogue of the library of Charles Darwin now in the Botany School, Cambridge*, 53, Cambridge, University Press, 1908. Most of the volumes contain numerous and very significant marginal comments, which I hope to discuss in another article.

[16] *Op. cit.*, Part III, 64, London, 1841.

[17] Charles Darwin, *The structure and distribution of coral reefs . . .*, 63, London, 1842.

[18] C. U. Library, Darwin Mss. **10.2**, fols. 26*c* and 26*d*.

[19] *Ibid.* **10.2**, fol. 42.

[20] *Ibid.* **10.2**, fol. 34.

When we start to consider the sources of Darwin's ecological insight, the importance of his personal experience is obvious. He began looking closely at insects and birds as a boy.[21] While a student at the University of Edinburgh, he kept notebook records of collecting at the seashore, and notes of bird watching.[22] At Cambridge he was an impassioned collector of beetles.[23] On the voyage of the *Beagle* he recorded numerous ecological observations in his journals and in his scientific notes.[24] After his return from South America he continued making such observations as were open to him in the English countryside. On his uncle's estate in Staffordshire, he studied the effects of enclosure and of planting of Scotch fir on the vegetation and the accompanying changes in insects and birds.[25] On his own lands he studied the struggle for existence of the components of the turf and the checks to increase of seedlings appearing on plots of cleared ground.[26]

Besides the influence of Darwin's field observations, there was the influence of his reading. In this connection we soon appreciate the significance of Darwin's warm tribute to Charles Lyell, the geologist, when he said that: "I never forget that almost everything which I have done in science I owe to the study of his great works."[27] The importance for Darwin of Lyell's discussion of the economy of nature and allied topics in his *Principles of Geology* is very clear.

At times Lyell used the phrase "economy of nature" as equivalent to "system of nature." Thus, he quoted John Playfair's *Illustrations of the Huttonian Theory of the Earth:* "Amid all the revolutions of the globe the economy of Nature has been uniform, and her laws . . . have remained invariably the same."[28] We can trace this usage as far back as 1658 in Sir Kenelm Digby's lecture on his powder of sympathy.[29]

But in the second volume of the *Principles*, which Darwin first received in Montevideo in September, 1832, Lyell's usage is ecological. Among the objectives of the volume, Lyell included examination of what today we would call ecological factors affecting the duration of species. As Conway Zirkle has pointed out, Lyell, like many naturalists before him, was aware of the pressure of population growth.[30] This awareness led him to comment on the "struggle for existence" in the following words:

> In the universal struggle for existence, the right of the strongest eventually prevails; and the strength and durability of a race depends mainly on its prolificness. . . .[31]

As Loren Eiseley has already shown, Darwin had encountered the idea of population pressure and the struggle for existence in Lyell's *Principles of Geology* and also in William Paley's *Natural Theology* long before he read Malthus.[32] The impact of Malthus on Darwin's thought was great largely because in 1838 when Darwin read Malthus' discussion of the "struggle for existence" it awakened echoes of ideas already familiar from his readings in Lyell, in Paley, and in other naturalists.

Lyell's references in regard to the economy of nature point directly back to the major earlier source: the writings of Carl Linnaeus. The importance of Linnaeus in the evolution of ecology is very great, and it is striking that among the naturalists writing after Linnaeus and before

[21] "From reading White's *Selborne* I took much pleasure in watching the habits of birds, and even made notes on the subject." *Autobiography*, 45. Darwin's introduction to the concept of the economy of nature was probably through Gilbert White, see *The natural history of Selborne*, Letters to Daines Barrington, XXXV.

[22] C. U. Library Darwin Mss. **5**, "Zoological walk to Portobello" (*ca.* 1826); item 129, Diary for 1826; see J. H. Ashworth, Charles Darwin as a student in Edinburgh, 1825–1827, *Proc. Roy. Society Edinburgh* **55**: 97–113, 1935, for discussion and excerpts of diary for 1827.

[23] *Autobiography*, 62–64, 1958; Leonard (Jenyns) Blomefield, *Chapters in my life*, 44, Bath, 1887.

[24] Besides the ecological observations in the 1st and 2nd editions of the *Journal of researches* . . ., of 1839 and 1845, and in the scientific notebooks published by Nora Barlow in *Charles Darwin and the voyage of the Beagle*, N. Y., 1946, there is some unpublished material in the Cambridge Darwin Mss. e.g. Vols. **31–32**, the original zoological journal, most of which was incorporated in the published *Journal of researches*.

[25] C. U. Library, Darwin Mss. **10.1**, fol. 43–49.

[26] *Origin of species, variorum text.*, ch. III, sent. 71–72.

[27] *The life and letters of Charles Darwin*, ed. Francis Darwin, **3**: 196, London, 1887.

[28] Lyell, *Principles of geology* **1** [ii], London, 1830. *Cf.* pp. 1, 63, 75, 76, 86, 112, 158.

[29] *A late discourse made in a solemne assembly . . . at Montpellier in France . . . touching the cure of wounds by the powder of sympathy* . . ., trans. R. White, 1st ed., 53, 74, London, 1658. The equivalent phrases also occur in the first edition of Paris 1658 and in the first Latin edition: *Discours . . . touchant la guérison des playes par la poudre de sympathie* . . ., 74, Paris, 1658; "Oratio de pulvere sympathetico," trans. L. Strauss, in *Theatrum sympatheticum* . . . 74, 100, Nuremberg, 1660.

[30] Conway Zirkle, Natural selection before the "Origin of species," *Proc. Amer. Philos. Soc.* **84**: 112, 1941.

[31] *Principles* **2**: 56, London, 1832.

[32] Loren Eiseley, *Darwin's century*, 180, 184, Garden City, N. Y., Doubleday, 1958.

Darwin, it is the geologist Charles Lyell who shows the clearest grasp of Linnaeus' ideas on the economy of nature and who makes the fullest use of them in his own work.

Before we examine Linnaeus' treatment of the economy of nature, we must consider for a moment the tangled question of authorship within the great Linnaean collection published in the ten volumes of the *Amoenitates Academicae*. Along with orations Linnaeus himself had delivered, he printed many doctoral dissertations which his students had originally published as their own. This requires some explanation.

In German and Swedish universities in the eighteenth century, the serious test of the student was the skill with which he conducted his oral defense of the thesis he presented. His major professor, who presided at the disputation, was often the author of the thesis to be defended. At Uppsala, Linnaeus generally dictated the essays which his students published and paid the printers' bill for.[33] He quite naturally regarded these dissertations as his own work. In a letter to his friend, the English naturalist, John Ellis, he wrote:

> The fourth volume of my *Amoenitates Academicae* is very nearly printed. . . . Among the dissertations I am about to publish are, *Genera morborum*, *Aer habitabilis*, *Flora Jamaicensis*, *Sus porcus*, *Anthropomorpha*, & *Generatio ambigena*. In the last of these I shall show that the brain and spinal marrow only proceed from the mother, and the rest of the body from the father.[34]

Nowadays, unless there is direct evidence to the contrary, it is customary to regard Linnaeus as the author of all these dissertations, and that policy will be followed in this paper.

After coming to know in the pages of Lyell's *Principles* ideas and facts from a number of these Linnaean essays, Darwin encountered Linnaeus himself, in English translation, in May of 1841. Under this date in his lists of books read, Darwin recorded two collections of papers. One was translated by Benjamin Stillingfleet, the other by F. J. Brand. Then he went on to the Latin *Amoenitates Academicae*. About this he wrote:

> Looked through 1 & 2 vols: I do not think much for me.[35]

The other Linnaean titles included in the lists of books read are: the *Philosophia Botanica*, the *Tour in Lapland*, and the *Fauna Suecica*. The eight works, including the *Oeconomia Naturae* and the *Politia Naturae*, which Darwin used in his manuscript on Natural Selection were all to be found in the collections of Stillingfleet or of Brand, however. From this year of 1841 on, Darwin made increasing use in his manuscripts, letters, and published works of the phrases "economy of nature" and "polity of nature."

To Linnaeus these phrases had overtones of natural theology. In the Swedish manuscript usually called "Linnaeus' Diary," he wrote:

> OECONOMIA and POLITIA NATURAE are two important arguments drawn at the same time from all three kingdoms of nature, and demonstrate theology or final causes . . . and the connection that subsists among created things, as to their production, conservation, and destruction.[36]

The Linnaean dissertation, *Oeconomia Naturae* of 1749, might be regarded as an expansion of the theme suggested by the question raised earlier by William Derham in his *Physico-Theology*, namely:

> how is it possible that so vast a World of Animals should be supported, such a great variety equally and well supplied with proper Food, in every Place fit for Habitation, without any especial Superintendency and Management, equal to, at least, that of the most prudent Steward and Householder?[37]

In the introduction to this dissertation "On the Oeconomy of Nature" we find the explanation of the three-fold character of Linnaeus' concept in these words:

> In order therefore to perpetuate the established course of nature in a continued series, the divine wisdom has thought fit, that all living creatures should constantly be employed in producing individuals; that all natural things should contribute and lend a helping hand to preserve every species; and lastly, that the death and destruction of one thing

[33] William T. Stearn, An introduction to the *Species plantarum* and cognate botanical works of Carl Linnaeus: VII. The *Amoenitates academicae* and the Authorship of Linnaean Dissertations, pp. 51–64 in Carl Linné, *Species plantarum: a facsimile of the first edition, 1753* 1, London, Ray Society, 1957. See also, Walter Artelt, *Einführung in die Medizinhistorik*, 184–185, Stuttgart, Ferdinand Enke, 1949.

[34] James Edward Smith, ed., *A selection of the correspondence of Linnaeus* 1: 125–126, London, 1821.

[35] C. U. Library Darwin Mss., item 119, Notebook listing books read, entries for 1841, May 8, 13, 14.

[36] Richard Pulteney, *A general view of the writings of Linnaeus*, 2nd ed., 558, London, 1805.

[37] William Derham, *Physico-theology: or, a demonstration of the being and attributes of God, from his works of creation*, 3rd ed., 214, [end of chap. XI], London, 1714. Linnaeus cites Derham in his *Oeconomia naturae*.

should always be subservient to the restitution of another.[38]

Linnaeus applied this cycle of propagation, preservation, and destruction to both the plant and the animal kingdoms. His study of propagation brought out differences in the potential rate of increase of different forms. Darwin used the figures for the high numbers of seeds produced by plants such as the poppy, published in Linnaeus' oration "On the Increase of the Habitable Earth," and analogous figures on arthropod egg production from Linnaeus' oration "On Insects."[39]

In connection with the propagation of plants, Linnaeus studied the dissemination of seeds. He discussed among the agents involved the wind, streams, currents in lakes and seas, mammals, and birds, all of which Darwin was to study deeply in his turn.

Under the topic of the preservation of plants and animals Linnaeus considered adaptation to climate and to habitat. He also alluded briefly to animals having their "allotted places" in the regions they inhabit. Later he wrote about insects that: "each of them has its proper business assigned to it in the oeconomy and police of nature."[40] Here Linnaeus seems to have glimpsed the germ of the concept Darwin was later to call "places in the economy of nature." In connection with the preservation of animals, in the "Oeconomy of Nature" he discussed the subject of the food of animals. In the "Flora of Insects" he considered the restrictions of the food choices of many insects. In the "Swedish Pan" he gave extensive lists of the food preferences of browsing live stock, in terms of species of plants eaten and plants rejected. Some of this information was also used by Darwin.

For the last phase of the cycle, he noted how the destruction of plants increases the mold of the soil. Under the topic of destruction of animals he treated what we would call food chains. For one example Linnaeus wrote:

> Thus the *tree-louse* lives upon plants. The fly called *musca aphidivora* lives upon the *tree-louse*. The *hornet* and *wasp fly* upon the *musca aphidivora*. The *dragon fly* upon the *hornet* and *wasp fly*. The *spider* on the *dragon fly*. The *small birds* on the *spider*. And lastly the *hawk* kind on the *small birds*.[41]

Often the destruction of large animals provides food for scavengers who also fit into the system. As he said:

> Thus the earth is not only kept clean from the putrefaction of carcases, but at the same time by the oeconomy of nature the necessaries of life are provided for many animals.[42]

To Linnaeus scavenging was also an aspect of the police of nature. This was treated in the dissertation, *Politia Naturae* of 1760. Politia can be translated either as polity or as police, and this ambiguity also appears in the contents of this essay.

It opens with a fanciful comparison of different types of plants with different estates of the realm:

> We may consider the *Mosses* as the poor laborious *peasants*. . . . The *Grasses* are the *Yeomany* of the vegetable kingdom. . . . *Herbs* may be looked upon as the *Gentry*. . . . The *Trees* are to be esteemed the *Nobility* of this state.[43]

This aspect of the *Politia Naturae* was summarized in the conclusion added by the English translator in the version Darwin read:

> Thus we see Nature resemble a well regulated state in which every individual has his proper employment and subsistence, and a proper gradation of offices and officers is appointed to correct and restrain every detrimental excess.[44]

This curbing of excess produced an equilibrium of population which Linnaeus often discussed. In particular the role of insects in maintaining a balance of nature was treated in his essays on "The Flora of Insects," "On Noxious Insects," "On the Study of Nature," and "On the Police of Nature." In the last named dissertation there was stress on the importance of "Those laws of nature by which the number of species in the natural kingdoms is preserved undestroyed, and their relative proportions kept in proper bounds."[45]

What Linnaeus called the police of nature involved, among other things, what we would regard as the most intensive kind of struggle for existence, as the following quotation will show:

[38] [Carl Linné, *praeses,*] I. J. Biberg, respondent, "The Oeconomy of Nature," in Benjamin Stillingfleet, trans., *Miscellaneous tracts relating to natural history . . .*, 3rd ed., 40, §1, London, 1775.

[39] C. U. Library, Darwin Mss. **10.1**, fol. 10 bis.

[40] Carl Linné, *Fundamenta entomologiae or, an introduction to the knowledge of insects*, trans. W. Curtis, 4, London, 1767.

[41] Linné, *praeses*, "The Oeconomy of Nature," in Stillingfleet, *Tracts*, 3rd ed., 114 §18.

[42] *Ibid.*, 122, §19.

[43] Linné, *praeses*, H. C. D. Wilcke, respondent, "On the Police of Nature," in *Select dissertations from the Amoenitates Academicae*, trans. and ed. F. J. Brand, 1: 134–135, Chap. I, §3, London, 1781.

[44] F. J. Brand, in *Select dissertations*, 164.

[45] F. J. Brand, *ibid.*, 131–132.

> Man, nature's last and most distinguished servant, to whose advantage and convenience almost all things are subservient, also maintains the balance of nature in many cases. The colossal whales in the ocean can scarcely escape his power; the fierce and ravenous beasts of prey, such as lions and tigers, he is forced to keep within bounds in order that he himself may enjoy peace; wherever there is an abundance of plants, trees, fish, birds and animals, he knows how to use them to his own profit. In this way he maintains a seemly balance so that nothing which is unprofitable may increase too much. But even man himself is subject to this same natural law, although I know not by what intervention of nature or by what law man's numbers are kept within fitting bounds. It is, however, true that the most contagious diseases usually rage to a greater degree in thickly populated regions, and I am inclined to think that war occurs where there is the greatest superfluity of people. At least it would seem that, where the population increases too much, concord and the necessities of life decrease, and envy and malignancy towards neighbors abound. Thus it is *a war of all against all!* [46]

[46] Linné, *Praeses, Dissertatio academica de politia naturae*, 16, Chap. I, §35, Upsala, 1760. Translation from Knut Hagberg's *Carl Linnaeus*, trans. Alan Blair, 183, London: Jonathan Cape, 1952.

And so in these essays of Linnaeus we have found a crude but meaningful presentation of ecology in its eighteenth-century guise. The familiar themes appear in primitive form in Linnaeus, reappear in Lyell, and then are transmuted by Darwin into vital elements of his theory of evolution. The economy of nature exhibits cycles of propagation, preservation, and destruction. An equilibrium of populations is maintained through the police of nature with checks to increase in numbers involving, implicitly or explicitly, the struggle for existence. Naïve teleology in Linnaeus gave way to agnosticism in Darwin, but ecological science grew in factual content and in significance.

We conclude with a paradox. The conventional statement is that Darwin overthrew the work of Linnaeus in so far as he replaced the orthodox dogma of fixity of species by his theory of evolution. But in regard to Linnaeus' concepts of an economy of nature Darwin used these ideas as major explanations of the workings of natural selection. So Linnaeus supplied major assistance for Darwin's arriving at his theory of evolution.

KNOWLEDGE: A GROWTH PROCESS

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(*Read November 13, 1959*)

IT seems appropriate for a member of the American Philosophical Society for Promoting Useful Knowledge to review for himself on occasions the philosophy by which useful knowledge is promoted. I have indulged in such a private exercise, not as a philosopher, which I am not, but as a practitioner of science. In our day, promotion of knowledge has become a public trust. Its managers and practitioners must see and keep the object—knowledge—in sharpest focus; lest it get blurred in the excitement of a mass-production boom, or get disjointed by progressive parcelling among producers, sponsors, distributors, interpreters, administrators, and consumers.

Promoting knowledge can only mean the fostering of its intrinsic growth. To do this rationally, requires insight into the nature of the growth process. I wish to show that fundamentally, our knowledge grows the way a living body does. The kind of knowledge I shall deal with is scientific knowledge; implying no inference to other forms. And even this limited perspective is slanted from the angle of my specialty, the life sciences. Yet, it takes the vantage point of a biologist to recognize the growth of knowledge as truly a mirror image of the growth of organisms. Not long ago, I summed it up as follows:

> Scientific knowledge grows like an organic tree, not as a compilation of collector's items. Facts, observations, discoveries, as items, are but the nutrients on which the tree of knowledge feeds, and not until they have been thoroughly absorbed and assimilated, have they truly enlarged the body of knowledge.

This thesis I shall now try to expound.

My model is a higher animal. The main steps of its growth process are diagrammed in figure 1. (Boxes indicate material entities; arrows, the flow of processes connecting them.) Growth converts food from the environment into body substance in a sequence of four major steps: intake, digestion, assimilation, and final utilization. The raw materials are gathered from the environment and either stored or passed on directly for alimentary processing. Digestible items are broken down chemically to more manageable compounds, which are then screened and sorted into useful and useless varieties. The wastes, together with undigestible residues, are eliminated, sharing the fate of spoilage from protracted storage. The

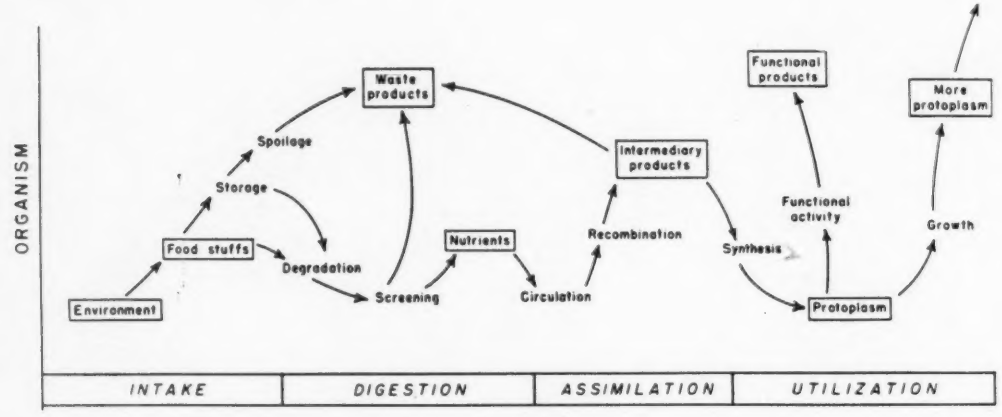

FIG. 1

useful fraction, the true nutrients, are circulated to the tissues, whose cells pick what they need, then recombine and modify it to form intermediary products, already bearing specific earmarks of that organism, some to be recirculated for use by other cells, some still to be discharged as waste; and finally, culminating the synthesis, each cell constructs from this supply pool selectively the substances and structures uniquely characteristic of its own kind. In this last step, cells branch in two directions: They either reproduce, that is, add more cells to the body; or they turn to the manufacture of special products, like fibers, hair, secretions, bone, and such.

This model is abridged and oversimplified. However, it illustrates the essence of the growth process; which is that in its growth an organism never adopts foreign matter outright, but reorganizes and assimilates it to fit its own peculiar pattern. Even a leech must first dissolve the hemoglobin of its meal of blood and then compose its own brand from the fragments. Organic growth is by assimilation, not accretion. Food items are not simply stuck on to the body, but on the contrary, lose their identity, become anonymous and indistinguishably blended into the body's very own type of constituents by the processing chain of extraction, screening, sorting, fitting, and recasting.

How closely this course is mirrored in the growth of knowledge, is symbolized in figure 2; the upper half repeating the organismic cycle, the lower half dealing with knowledge, beginning from its source—experience, still unprocessed. Probing of the environment furnishes the raw data of information, which are either stored as records for future use or analyzed forthwith. The products of analysis are then screened and sorted according to relevance. Irrelevant ones go into discard, sharing the fate of records become obsolete. And from this sorting, the pile of data emerges as an ordered system, catalogued and

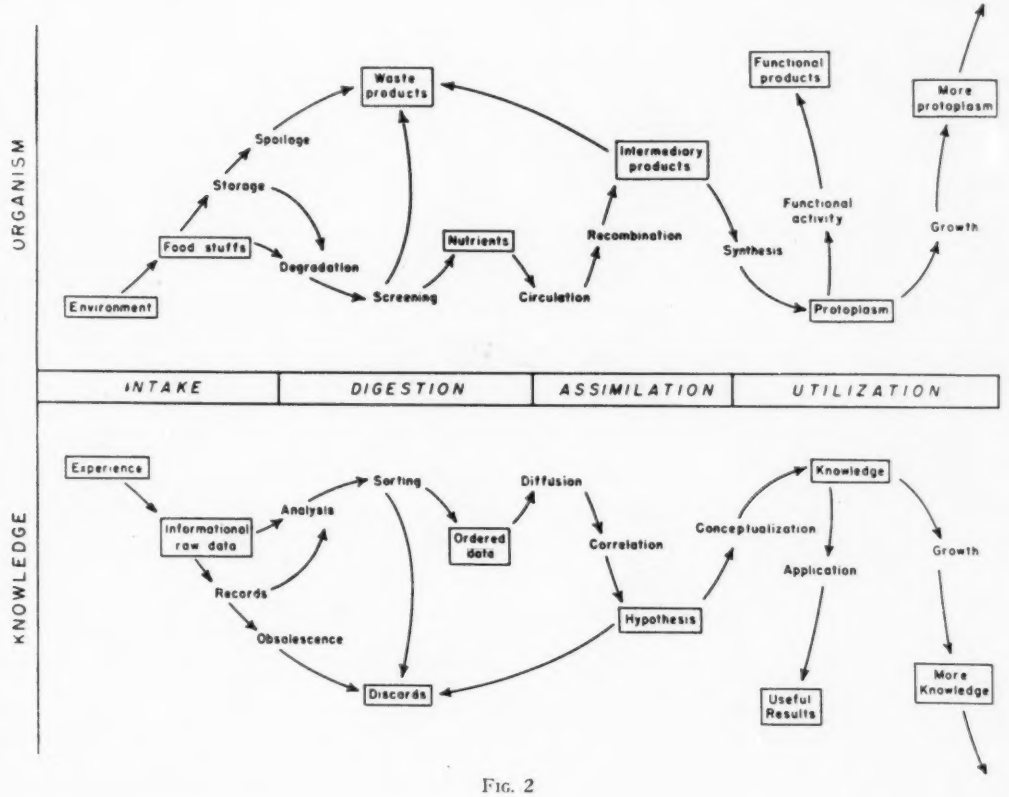

FIG. 2

classified, yet each item still revealing its erstwhile identity. The grandest examples of such ordered sets of data are perhaps the Linnaean system of species prior to the theory of evolution, or the Mendelyeev Atomic tables prior to modern physics. In various stages of evaluation, such packaged information is then widely circulated, leading to confluence and critical correlation with countless contributions from other sources. From this synthetic process, hypotheses emerge, which upon further verification, turn into integral parts of the body of knowledge—theorems, principles, rules, and laws—general formulae which not only supersede the itemized accounts of the very data from which they were derived, but can dispense with the further search for items of information, which they predictively subsume.

At this stage, data have become assimilated, have lost their individual identities in merging with that higher entity—the body of organized knowledge. Sheer listing has given way to understanding. A patch work of unrelated facts has been transformed into a rationally connected thought structure of inner consistency, viable and durable, subject to the tests of survival and the adaptive improvements of evolution—a veritable model of an organism. As in the organism, the culminating phase is branched: as basic knowledge grows, part of the increment accrues to its own body, yielding more basic knowledge, while another part is converted into differentiated products—all that is commonly lumped under the attribute "applied."

Note that no separate express tracks connect either food stuffs directly with functional products in the organism, or informational data with practical results in human affairs, but that both must be routed through the common machinery for growth. In knowledge, as in nature, fruit grows on trees and cannot be raised directly on the soil by short cuts by-passing the tree.

Our growth analogy could be expanded—tradition standing for heredity; novel ideas, for mutations; the "team" approach, for symbiosis—but the general parallelism will have become clear enough for us now to examine its implications.

In the first place, it shows that information is not tantamount to knowledge. Information is but the raw material, the precursor, of knowledge. To hoard a store of unrelated items of information in a mental gullet by rote memory and without sense of relevance—including the ability to regurgitate the data on a quiz master's prompting—should pass for knowledge no more than the stuffing of a hamster's pouch can be regarded as growth. Knowledge emerges from the distilling, shaping, and integrating of the raw material into concepts and rules; and in this process of condensation and generalization, the number of bits of detailed information dwindles, rather than mounts: a piling up of raw data signals glut rather than growth.

Accordingly, if knowledge grows like organisms, we ought to observe sound dietetics and avoid unhealthy overstuffing; the symptoms of glut—redundancy, superdetermination, oversophistication, and just plain bulk—are already noticeable in current research practices. Part of the syndrome carries rather undignified names, such as "soft money" or "projectitis." But the crucial ailment is myopic vision, which fails to recognize the true character of knowledge. Once out of sight, the body of concepts to which data collection should be related, no longer guides the search for data. The sense of relevance and selectivity becomes atrophic, composing stops at sheer compiling, search becomes pointless, and freedom of investigation degenerates into license for random movements.

The diagnosis calls for preventive therapy. One nostrum proposes that research be governed, with social utility as beacon. Unfortunately, the diet this prescribes for knowledge is of the sort that social insects feed to their larvae to mold them to preordained stations in life, mostly soldiers and sterile workers, instead of nurturing versatile and reproductive specimens. By contrast, I submit that knowledge grows best on a liberal balanced diet based on variety and wide freedom of choice, free of excessive roughage.

Now, who is there to write the formula? We all abhor the notion of an all-wise potentate of knowledge, whether person, institution or society, to rule on what will, and what will not, promote the growth of knowledge. But there is one wizard, who has the formula and gladly hands it over for the asking—history, which has watched knowledge grow from infancy. It tells us that the key agent in the growth of knowledge has always been the human mind, imaginative, critical, and integrative; devising robots, tools, techniques, merely as aids to extend the limited reach of man's perception and control, but never abdicating the functions of evaluation and invention. Promoting knowledge, therefore, implies giving full scope to the exercise of the faculty for assimilation and synthesis by which the mind converts facts to knowledge. The history of knowl-

edge contains the rules to give those bent on promoting knowledge by either doing or supporting research, the necessary cues for intelligent and responsible self-direction. The stress here lies on "self"; there is no need for forcible external steering: Bearings for self-steering are needed. But how could the uninitiated self orient itself purposefully if we hide or blur the goal? Or do we expect each self to re-discover the goal for himself by trial-and-error, fumbling and floundering in semi-darkness, when we could readily draw on the lessons of the past to illuminate both goal and path?

You realize what I am driving at. As educators we mold tomorrow's promoters of knowledge. We must be far more explicit than we have been lately in teaching them not just the present state of knowledge, but the way in which it has grown up to here, which is the only way in which it can grow further. Inspired teachers teach and practice it, but they are too few. Some students find it by themselves, but not enough of them. So, let us restore to education some fundamentalism—making explicit to the student the fundamental bearings needed for him to chart his own course in clear view of what furthers knowledge, and what does not, instead of letting him drift in the cross currents of traditional momenta and alluring fashions. Ideas—yes, even well-founded speculation—should find a respectful place again among the shining gadgets. And his critical mind, rather than the board room of a fellowship or grants committee, should become again the primary testing and screening ground for relevance. If he finds data, let him explain their meaning. And if he can't he should have a sense of incompleteness, and not of glee over having prevented mental contamination of nature. Let editors encourage, rather than blue pencil, an author's interpretive excursions. And let the whole process of fostering knowledge become refocussed on penetration and concentration, instead of sheer expansion and bulk. Or else, knowledge—an organism—might come to share the fate of the dinosaurs.

Yet, notwithstanding this plea for more thorough digestion and mental processing of data, there is another side of nature which is refractory to this treatment and does not fit our analogue at all. I am referring to those phenomena whose constellation in space or seriation in time is so unique that generalization would obliterate their most relevant features. We can establish general principles of parasitism, but each species of parasite has its own peculiar life history, which must be known as such. Chemical chain reactions must conform to thermodynamic law. But just what sequence of steps constitutes a given metabolic cycle, must still be determined separately in each instance. Despite their common name, each hormone has its own special way of operating, and each disease has its specific course. In other words, the information which in the search for basic knowledge would merely be a way station, becomes a terminal; to remain useful, its itemized character must be preserved.

This seems the proper province of automation, relegating increasingly to technological devices the jobs of recording, scanning, sorting, reducing, storing, and retrieving data. But even here human intelligence will have to judge what to explore and to record. As every single walnut is unique, can we afford to go on indefinitely shelling walnuts and loading down our libraries with records of their physiognomies? Certainly not, unless there is a point to it. To make the point, is up to the investigator. But it is up to educators to imbue investigators with a sufficient sense of relevance and responsibility as to abstain from pointless tasks. Self-direction must not be let lapse into self-indulgence. But how draw the line? Whether to stop at pragmatism or to go on to generalize, varies, of course, with subject matter, need, and interest; but above all, perspective.

To gain perspective, let us again turn to history.

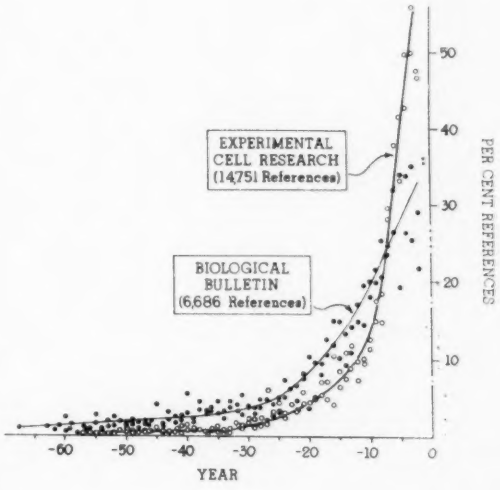

FIG. 3

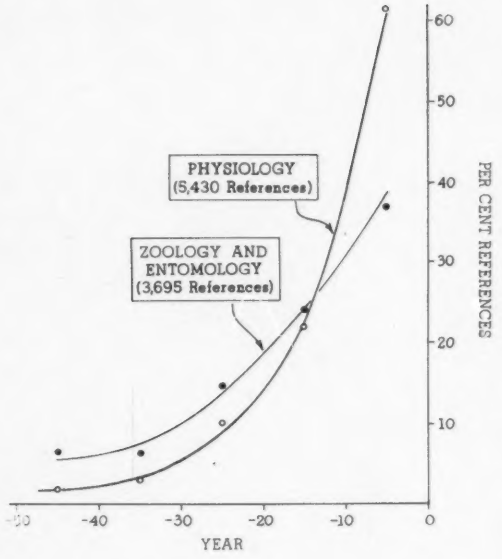

FIG. 4

What is—so we may ask—the real fate of plain recorded data? What is their life expectancy, and does it differ substantially for data that can be generalized and those that cannot? Since mere occupancy of library space is no criterion of life, as against mummification, I made a little actuarial study using as gauge of relative vitality of data the frequency with which they are referred to in the literature.

For comparison, I chose two biological journals: *Experimental Cell Research*, with a strongly analytical emphasis, and the *Biological Bulletin*, with a larger descriptive bias. I tallied all references, except self-citations, by all authors year by year over a 10-year period and plotted the percentage frequency with which publications were cited lying back 5, 10, 15, 20, and so forth, years. This graph (fig. 3) shows the results which are quite striking.

For each of the two journals, the annual percentage frequencies define with remarkable consistency a single curve, whose course expresses the rate of obsolescence of publications. The steepness of its slope should give us pause. No more than 50 per cent of the annual references in *Experimental Cell Research* date further back than five years, and still older literature is rapidly lost sight of. By contrast the flatter curve for *Biological Bulletin* reveals a much greater dependence on older records. The difference is highly significant. To validate it further, I plotted the chronological frequencies of back citations during 1952–1954 in the major journals in physiology and in zoology and entomology (fig. 4) from a report by C. H. Brown on "Scientific Serials," and obtained an essentially similar pair of curves, both dropping off sharply, but the drop being much steeper in analytical physiology than in its more descriptive biological sister sciences.

The lessons of this actuarial census of literature thus are twofold: In the first place, the active life span of pure data is at any rate amazingly short: they die of either assimilation or oblivion. And second, the less they lend themselves to assimilation, the longer they remain useful individually.

This leads me to conclude as follows: Each field of knowledge must be accorded its own merit ratio between generalization and particularization; taking for granted that assimilation will be driven to the utmost limits compatible with the nature of the field. Yet, in view of the rapid attrition of *all* unassimilated information, a radical reorientation of our publication policies would seem warranted, based on introducing the principle of actuarial tables, about as follows:

In each discipline separate media of publication would be established for classes of communications of different life expectancies. Each author of a manuscript would assess its prospective useful life span—presumably with the benevolent advice of editors—on a rating scale extending from the ephemeral technical note at the low end to the great synthetic opus at the other; the paper would then be allocated to the corresponding fast-aging or slow-aging class of serial. Each serial volume would be kept on library shelves only for the time span allotted to its class, and then discarded; excepting a few libraries specifically designated as permanent historical repositories. Some such deliberate scheme would go far in restoring and preserving a reasonable ratio of payload to ballast in our records of knowledge.

Graded in terms of relevance, not every observation is worth reporting; not every report is worth recording; not every record is worth publishing; and not every publication is worth preserving for eternity, except in sample specimens as in Noah's Ark. I submit that this grading can still be left to the investigators and their peers, as long as they are cognizant of the true nature of knowledge as a growth process, of which assembling facts—of food for thought—is but the first preliminary step; a growth process,

moreover, which often thrives better on a spare, than on an overly rich, diet and in which self-restraint can readily ward off obesity.

So in conclusion, and dropping parabolic language, the effective pursuit of knowledge is intimately linked to the old virtue of disciplined research morale which will not countenance the substitution of bigness for greatness, gadgets for intellect, projects for ideas, and man-hours for thought; although it must rely to the fullest on technical relief by gadgets and man-hours in those auxilliary services which do not require the intervention of a constructive mind.

As I said at the outset, my comments are confined to *scientific* knowledge. Its steady long-range growth has still immense potential scope. We should not let it get diverted, inflated, and unbalanced by pressures for short-range crash spectaculars. More than ever, our key words should be "balance" and "perspective."

MEMOIRS OF THE
AMERICAN PHILOSOPHICAL SOCIETY

Erwin Frink Smith—A Story of North American Plant Pathology. ANDREW DENNY RODGERS III.
Vol. 31. x, 675 pp., 4 figs. 1952. $5.00.

The Primitive City of Timbuctoo. HORACE MINER.
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